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OF

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RECORDS

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ON THE AGE AND CONTINUATION IN DEPTH OF THE MANGANESE-ORES OF THE NAGPUR-BALAGHAT AREA, CENTRAL PROVINCES. BY L. LEIGH FERMOR, A.R.S.M., D.SC., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 1 to 3.)

IN *Memoirs, Geological Survey of India*, XXXVII, (1909), Chapters XIV to XVII, I have discussed somewhat fully the origin of the manganese-ore deposits found in association with the rocks of the gondite series (gondite being spessartite-quartz-rock).

Distribution of the gondite series.

The rocks of this series have been found in the following provinces, reading from west to east :—Bombay, Central India, Central Provinces, and Bengal; and probably in Rajputana also. The chief development of the series is in the Nagpur-Balaghat area of the Central Provinces, comprising the districts of Chhindwara, Seoni, Nagpur, Bhandara, and Balaghat ; and it is from this area that most of the facts used in this discussion are derived. The conclusions given on pages 364 and 365 of the work cited, as to the origin of the gondite series and the associated manganese-ores, are repeated here to save lengthy explanations :—

Origin of the series.

Conclusions as to the Origin of the Gondite Series and the Associated Manganese-ores.

> The conclusions at which I have arrived in the foregoing pages are much more open to doubt than those regarding the origin of the ores of the kodurite series, the reason

being the smaller amount of evidence obtained. The points that may be considered fairly certain are the following:—

1. The rocks of the gondite series are the product of the metamorphism of the less pure manganiferous sediments of Dhárwár age, the metamorphism of these sediments having taken place towards the end of the Dhárwár period.
2. A portion of the ores has been formed directly by the compression of the purest of the original manganese-oxide sediments.
3. Another portion of the ores has been formed by the subsequent alteration of the manganese-silicates produced by the above-mentioned metamorphism.

The points that are to be considered as more doubtful are put forth below. Even if they do not express the whole truth, I believe that they form an approximation to it; any way, together with the points given above, they form a working hypothesis that will suggest to a future geologist the evidence to look for in trying to put the theory as to the origin of these manganese-ore deposits on a surer footing.

4. The ores formed by the alteration of the rocks of the gondite series were formed by a combined decomposition and replacement of the gondite, spessartite-rock, or rhodonite-rock, as the case may be.
5. The alteration of manganese silicates to manganese-ores took place at the close of the Dhárwár period of folding, and hence in Archæan times.
6. The alteration took place at considerable depths, so that, taken in conjunction with the supposition that a portion of the ores are merely compressed manganese-oxide sediments, workable manganese-ores may be expected to extend in some places to as great a depth as the rocks of the gondite series.
7. The alteration was due to the attack on the manganese-silicate-rocks by waters containing either carbon dioxide or sulphuric acid, more probably the former; and also oxygen.
8. The carbon dioxide may have been a portion of that liberated in the conversion of original impure calcareous sediments into the quartz-pyroxene-gneisses of this area; and the oxygen a portion of that liberated in the conversion of original impure manganiferous sediments into the manganese-silicate-rocks.
9. A small proportion of softish and more or less porous ore has been formed since the rocks of the gondite series were exposed at the surface, and is probably still being formed.

Objects of this paper.

The *primary object* of this paper is to show that the majority of the manganese-ores of the Central Provinces[1] were formed in Archæan times; the word Archæan being used, in the sense proposed by Sir Thomas Holland,[1] to include all the rocks below what he calls the great Eparchæan Unconformity, *i.e.,* to include not only the most ancient crystallines, but also the Dhárwárs, and the gneissose granites, pegmatites, and other igneous rocks of post-Dhárwár age that are not intrusive with regard to the division of the pre-Cambrian rocks, known as the Puranas, lying above the Eparchæan Unconformity.

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[1] Manganese-ores are found in other parts of the Central Provinces besides the Nagpur-Balaghat area, *e.g.*, in the Jubbulpore district; but in this paper by the Central Provinces is meant the gonditic area, or Nagpur-Balaghat area, of the province.

The *secondary object* is to indicate that, in all probability, these Archæan ores were formed at some depth below the earth's surface and not by any method of superficial replacement or concentration ; so that the present position of the surface bears no particular relation to the depth to which the ores extend.

Ores formed in two ways.

Now the larger portion of the manganese-ores of the Central Provinces has probably been formed in the ways specified above in conclusions 2 and 3, those formed according to conclusion 9 being of little importance. That the ores formed by method 2 are of Archæan age needs no further proof here, since they must have been formed at the same time as the associated manganese-silicate-rocks (see conclusion 1). But that the formation of the ores produced according to method 3 took place in Archæan times by no means follows.

The difficulty is that at present there seems to be no way of determining what proportions of the ores are to be ascribed to methods 2 and 3, respectively. In many cases where the ores contain residual patches of gondite, spessartite-rock, or rhodonite-rock, the evidence is very clear that the ore has been formed by the chemical alteration, accompanied by replacement, of the manganese-silicate-rocks. But in cases where the masses of ore are pure and homogeneous, it is often impossible to say whether the ore has been formed by the completion of the process of alteration and replacement of the manganese-silicate-rocks (method 3), or whether we are dealing with masses of ore formed by the direct compression of original manganese-oxide sediments (method 2). Could it be shown that the larger proportion of the ores has been formed by method 2, the determination of the age of those formed by method 3 would be of much less importance. But this cannot be shown, and therefore the determination of the time of conversion of manganese-silicate-rock to manganese-ore—*i.e.,* the establishment or overthrow of conclusion 5 on page 2, becomes a matter of importance.

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[1] *Trans. Min. Geol. Inst. Ind.,* I, p. 47, (1906).

Time of alteration of silicate-rocks to manganese-ore.

On pages 355 and 356 of the work cited it is shown, on evidence derived from the Central Provinces, that the alteration must have taken place previous to the erosion of the present topographical features of the country ; but at the time this was written no evidence had been obtained from the Central Provinces showing at what particular past time or times, ranging from Archæan almost to recent, this change took place.

Nevertheless, the rarity of open spaces in the manganese-ore deposits of this area, and the compact characters of the ores, are held to indicate that the alteration took place prior to the last set of earth movements powerful enough to close up open spaces formed during the chemical changes by which the ores were formed. And since none of the post-Archæan earth movements of which we have evidence seem to have been powerful enough for this, judging from their effects on post-Archæan rocks, the non-cavernous nature of the deposits is held to be another piece of evidence pointing to the Archæan age of the alteration process (*l. c.*, p. 363).

Evidence at Jothvad, Narukot.

Further, there is at Jothvad, Narukot State, Bombay Presidency, a small hill of banded gneissic and schistose rocks, including members of the gondite series, invaded by apophyses of a porphyritic biotite-granite of presumed Archæan age ; pieces of manganese-silicate-rock, of manganese-ore, and of manganese-silicate-rock passing into manganese-ore, are enclosed in the granite, showing that the manganese-ores of this hill were already in existence at the time of intrusion of the granite, and that, in so far as any of the ores can be shown to have been formed by the alteration of manganese-silicate-rocks, this alteration process dates back to Archæan times (*l. c.*, pp. 320, 321). And, arguing by analogy, it is held that the alteration of manganese-silicate-rocks to manganese-ores in the Central Provinces probably took place in Archæan times also.

Intrusives into the manganese-ores.

Many cases are known in the Central Provinces of acid intrusives (granites and pegmatites, and allied rocks), piercing the gonditic and associated manganese-ores (*e.g.*, at Ramdongri, Beldongri, Kacharwahi, Kosumbah). These intrusives frequently contain abundance of manganese-bearing minerals (*e.g.*, spessartite, blanfordite, and braunite).

But the manganese these rocks contain might have been derived either from the gonditic rocks or from the ores formed by method 2, and so cannot be taken as indicating the existence prior to the intrusion of these rocks of the manganese-ores formed by alteration. Further the fact that the igneous rocks are intrusive with reference to the manganese-ores cannot be regarded as conclusive evidence of the Archæan age of the ores formed by alteration; (1) because the ore invaded may be original ore formed by method 2, and (2) because the intrusives themselves are often partly converted by replacement into inferior ore, which might have been formed during the alteration of silicate to ore, or may be due to unimportant secondary changes in the deposit subsequent to the main alteration.

In fact, the time when this alteration took place can never with certainty be affirmed as Archæan, unless inclusions of the partly altered manganese-silicate-rock can be found in the intrusive, or unless examples can be found in which the ore into which the igneous rock is intruded has manifestly been formed by the secondary alteration of manganese-silicate-rocks prior to the eruption of the igneous rock. (In this case [1] the process of alteration that has affected the manganese-silicate-rock, with its partial conversion into ore, will be found to end abruptly at the contact of the manganese-silicate-rocks and ores with the intrusives.)

In view, therefore, of the paucity of evidence relative to the age of these manganese-ores, it is very important to put on record some evidence similar to that of Jothvad obtained on a visit to the Gowari Warhona deposit in the Chhindwara district, in November 1908.

I re-visited this deposit on the suggestion of Mr. Hance, Manager of the Indian Manganese Co., Ltd., who reported that the deposit was showing signs of serious deterioration in depth. I almost expected to see a case of passage downwards from manganese-ore of good-quality into a zone of but partly-formed ore showing abundant remains of gonditic rocks. Such partly-formed ore does exist in this deposit, but I did not find the amount of it to increase with depth. Instead, I found that there was no deterioration in the quality of the ore apparent to the eye, and that the deterioration of the deposit with increasing depth was due to numerous intrusions of pegmatitic rocks, the eruption of which seemed

Gowari Warhona, Chhindwara district.

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[1] *Cf.* (2) of previous para.

to have been the cause of the frequent folding, doubling and faulting of the deposit, with in places the complete disappearance of the ore band. [The account of this deposit given on pages 795 to 800 of the work already cited was based on my first visit (in 1903), when little evidence of this disturbance was visible.] Plate 1, fig. 1, shows a section in which the ore beds are seen abruptly truncated by the pegmatite intrusion. Plate 2, fig. 1, shows a pegmatite vein cutting right across the ore band.

Pegmatites.

These pegmatitic rocks, which do not show graphic structures, are very coarse-grained, with felspar (usually microcline, as far as I have tested it) as chief constituent, and with subordinate amounts of quartz (not always present); yellow manganese-garnet and bronze-brown mica are also sometimes present.

Enclosure of manganese-ore in a felspathic vein.

At one point in the main or eastern portion of the workings I found a veinlet (varying from 1½ to 3½ inches thick) of coarse white felspar (microcline)-rock containing dark bronze-brown mica and microscopic apatite. In this veinlet, which cut across the strike of the ore-band, was enclosed a piece of manganese-ore showing a pentagonal section on the exposed surface. It was 1½ inches across and looked exactly as if it were a piece broken off from the adjoining main mass of the ore-body at the time of the pegmatite intrusions. A photograph of it is shown in Plate 1, fig. 2. In order to be quite certain that this really was an inclusion and did not unite, behind, with the main mass of manganese-ore, I picked away the pegmatite with a pick-axe; the manganese-ore came out in five pieces fitting together, the last piece having a rounded end fitting into a corresponding socket in the pegmatite. Unfortunately one of these pieces was lost amongst the debris in the quarry, but the remaining four pieces are now in the Geological Survey collection (22·87) and are shown in Plate 3, fig. 1. Of course, one cannot be certain that the other end of the inclusion (the front part that had been broken away before my visit) was also free and not connected to the main mass of the manganese-ore, but it seems extremely probable that such was the case. The manganese-bearing-ore of this inclusion is a fairly coarsely crystalline ore (largely braunite), identical in appearance with the ore forming the walls of the veinlet (see specimen 22·87).

Manganese-ore older than the pegmatitic intrusions.

I regard this inclusion as an almost certain proof that when the pegmatitic rocks were intruded into the manganese-rocks, this particular variety of manganese-ore was already in existence in the form in which it is now found. Figure 1 of Plate 1 shows the manganese-ore beds cut off abruptly by an intrusive mass of pegmatitic rock, and forms another almost certain proof that the manganese-ore beds were in existence before the intrusions took place. Had the ores been formed by alteration of manganese-silicate-rocks subsequent to the pegmatitic intrusions, the alteration would not have extended only to the line of junction with the pegmatite and no further; the pegmatite itself would have been partly replaced. (That changes have taken place since the intrusions is shown by the fact that in some other exposures the pegmatite is blackened by impregnation with manganese oxide along cleavage planes of the felspar, accompanied by partial replacement; and in some cases soft manganese-ores have been formed.) The conclusion deduced from the occurrence described above is supported by another specimen of manganese-ore found included in a mass of pegmatite close to the pentagonal inclusion already figured (see specimen 22·70 and figures 2 and 3, Plate 3). This pegmatite is composed of microcline with a little quartz, and a mineral so altered that it cannot be identified.

Manganese-ores of Archæan age.

Reviewing the evidence advanced above, it seems certain that a large proportion of the Gowari Warhona ore—particularly the hard crystalline variety—was in existence in approximately its present mineralogical condition before the irruption of the pegmatitic rocks. There is no reason to suppose that these pegmatite intrusions are of later age than Archæan (though they are, of course, post-Dhárwár). Hence it is almost certain that these ores are of Archæan age. But although the evidence as to the age of these ores is fairly conclusive, it is not possible to state with certainty whether they have been formed by the direct compression of manganese-oxide sediments (*i.e.*, by method 2, page 2), or whether, on the other hand, they have been formed as the result of the secondary alteration of manganese-silicate-rocks (method 3), themselves the product of the metamorphism of manganiferous sediments such as gondite. But, owing to the existence in this deposit of considerable amounts of gondite and spessartite-rock, often showing the various stages of conversion into manganese-ore, I am inclined to think that the Archæan, hard, crystalline ores of this deposit are largely, if not entirely, the product of the alteration of gonditic rocks; if so, then we have the proof at this locality that this alteration took place prior to the pegmatite intrusions, and therefore in Archæan times. But unless some one can find a piece of gondite included in the pegmatite, and showing all stages of conversion from garnet to ore, without any signs of secondary introduction of manganese oxide into the pegmatite from the inclusion, it cannot be regarded as certain that any of this Archæan ore was formed by the alteration of gondite.

Gonditic rocks probably altered in Archæan times.

Nevertheless, comparing the evidence obtained at Gowari Warhona with that from other parts of the Central Provinces (see page 4), we see that everything points in one direction, namely, that the alteration of the manganese-silicate-rocks to manganese-ores took place in Archæan times. And as the ores formed by direct compression of original manganese-oxide sediments must also have formed in Archæan times (see page 3), we can regard the first proposition of this paper as established, not conclusively, but with great probability; namely, *that the larger part of the manganese-ores of the Central Provinces associated with the gondite series was formed in Archæan times.*

Depths at which alteration took place.

Since, as far as is known, rocks as coarse-grained as pegmatites can be formed only at considerable depths, it follows that the manganese-ores must have been at a considerable depth at the time of intrusion of the pegmatite.

That the ores formed by the alteration of gonditic rocks were formed at this depth by no means follows; but that they were formed at depths, also considerable, but not* necessarily as great as those at which the pegmatite intrusions took place, does follow in an indirect way. For the alternative hypothesis would be that the alteration of manganese-silicate-rocks to manganese-ore took place near or at the surface in Archæan times, that the ores and associated rocks were then buried to a considerable depth in the earth's crust and invaded by pegmatitic intrusions (also in Archæan times), and that by subsequent denudation during the ages between Archæan and almost recent times the overlying rocks were eroded to such a depth that the manganese-ores were again brought to the surface, or very near to it. This would be such a remarkable coincidence that it seems improbable.

Hence it is much more probable that the alteration took place in depth.

The fact that the alteration of manganese-silicate to manganese-ore is essentially an oxidation process, which is usually supposed to be characteristic of small depths, is by no means an insuperable barrier to the hypothesis that the ores were formed in depth. In the work already cited (*l. c.*, pp. 362 and 363) it is shown that the carbon dioxide and oxygen required for these changes may have been expelled at considerable depths, the former from impure calcareous sediments at the time of their conversion into quartz-pyroxene-gneisses by metamorphic agencies, and the latter from the original impure manganese-oxide sediments at the time of their conversion into the manganese-silicate-rocks of the gondite series by the same agencies. The gases thus liberated during these metamorphic processes may have remained in or close to the rocks so formed, and have been available for an attack on the manganese-silicate-rocks on the release of the pressure to which the liberation of the gases was due (see conclusions 7 and 8, page 2).

And if the alteration of manganese-silicates to manganese-ores took place at considerable depths, there is no reason, in view of the *modus operandi* suggested, why the alteration should not have taken place in the gondite series at any depth whatever; that is, there is no more reason why the portions of the gondite series situated at the bottoms of synclinal basins should have escaped alteration into manganese-ores than holds for those portions situated nearer the surface; the controlling factors in the alteration were more probably the presence or absence of the oxygen and carbon dioxide required to effect the changes, and not the depth at which the rocks were situated.

From the considerations put forward in the foregoing paragraphs, the probable truth of conclusion 6 (page 2) is established; namely, that *the alteration of manganese-silicates to ores took place at considerable depths, and that manganese-ores may be expected to extend in some places to as great a depth as the rocks of the gondite series.*

Practical Considerations.

We have now established with a fair degree of probability that the larger portion of the manganese-ores of the Central Provinces was formed in Archæan times, and at considerable depths. This, if true, means much to the miner. No longer need he fear that most of the manganese-ore deposits of the Central Provinces are of superficial origin, and that they will therefore disappear, or become worthless, at small depths. In many cases he will probably find that they *continue to as great a depth as the rocks of the gondite series.* Where the present surface of the ground happens to cut the bottom of a synclinal trough of gonditic rocks, the truth of the statement italicised above will soon be revealed by quarrying, and in addition, the manganese-ore deposit will give out quickly. And where the sheet of gondite and associated manganese-ores is in the shape of a lenticular intercalation amongst the Archæan gneisses, schists, and quartzites, it may happen that the surface of the ground cuts the lenticle of ore near its lower edge, and in this case also the gondite and ore will soon tail out in the workings. Or again, the gondite may be altered to ore only in patches, so that in some cases it may give place to but partly altered or fresh gondite at a small depth; but in this case the ore may re-appear at greater depths, when another patch of altered rock is reached.

But when all these possible cases, of disappearance of workable ores at small depths, have been eliminated, there probably remain several in which the gonditic rocks and associated ores persist to considerable depths, even down to 1,000 feet.

From this it is seen that the manganese-quarrying industry of the Central Provinces need not come to an end when all the known deposits have been worked by opencast methods as deeply as is possible or profitable. For it is probable that in many cases ores will continue for some depth below the opencast levels; and further it is possible that in a fair proportion of these cases the ore will be of workable quality. This means that in the future quarrying will probably be replaced by underground mining. But before an attempt is made to work any deposit by underground methods, the downward extension of the deposit should be proved, preferably by bore-holes to a depth of 200 to 300 feet below opencast levels in the first place, supplemented by a few holes of greater depth later on. The extension of the ore to lesser depths could of course be proved by sinking incline shafts on the ore-band, thus proving the ore and winning some of it at the same time.

At present, doubtless because of the large quantities of opencast-ores still in sight, there seems to be no desire amongst the manganese-mining community of the Central Provinces to obtain any idea as to the magnitude of their underground reserves of ore, the probable existence of which in many cases is indicated by the evidence adduced in the preceding pages.

Application to Other Areas.

It seems hardly necessary to point out that, if I am correct in correlating the gonditic manganese-ore deposits of other parts of India with those of the Central Provinces, the general proposition upheld in this paper—concerning the depth at which the alteration of manganese-silicate-rocks to manganese-ores took place, and consequently the depth to which the manganese-ores may be expected to extend—may be applied also to these other manganese-ore deposits.

EXPLANATION OF PLATES.

PLATE 1.

Fig. 1. Manganese-ore beds (A) cut off by pegmatite (B). Gowari Warhona, Chhindwara district.

„ 2. Pegmatite vein with an included pentagonal fragment (A) of manganese-ore, cutting manganese-ore beds. Gowari Warhona.

PLATE 2.

Fig. 1. Felspathic dyke cutting manganese-ore body. Gowari Warhona.

„ 2. General view of Gowari Warhona.

PLATE 3.

Fig. 1. The jointed inclusion of manganese-ore obtained from a pegmatitic vein at Gowari Warhona (see Plate 1, fig. 2). Natural size.

Figs. 2 and 3. Two portions of another inclusion of manganese-ore in pegmatite. Gowari Warhona. Natural size.

NOTES ON THE MANGANESE-ORE DEPOSITS OF GANGPUR STATE, BENGAL, AND ON THE DISTRIBUTION OF THE GONDITE SERIES IN INDIA. BY L. LEIGH FERMOR, A.R.S.M., D.SC., F.G.S., *Superintendent, Geological Survey of India.*

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II.—THE DISTRIBUTION OF THE GONDITE SERIES IN INDIA.

I.—THE MANGANESE-ORE DEPOSITS OF GANGPUR STATE.

On page 615 of Vol. XXXVII of the *Memoirs of Geological Survey of India* (1909), I have referred to the occurrence of manganese-ore in this State. Since writing this I have paid a very brief visit (in December 1908) to the two chief deposits discovered. They had not been opened up to an extent sufficient to justify a careful survey, and therefore the following account must suffice for the present.

History.

Manganese-ores were first found in this State by Mr. Isaac Schrager, prospecting on behalf of Babu Madhu Lall Doogar, early in 1907; and a prospecting license for 3 years over 96 square miles was obtained in the same year from the Feudatory Chief of the State. The two chief occurrences are at Gariajhor and Birbira (Kusummunda), the former of which is only 7 miles from Dharuadihi station on the Bengal-Nagpur Railway, to which it has been connected by a light steam-tramway built by the Gangpur Light Tramway Co., Ltd., floated for this purpose. The capital of this company is Rs. 2,50,000, and the managing agents are Messrs. Grossmann & Co. of Calcutta.[1]

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[1] For an account of this tramway, opened on January 16th, 1909, reference may be made to the *Indian and Eastern Engineer*, New Series, XXVI, pp. 96-8, (1910).

Production.

The production in this State during the years 1908 to 1910 was as follows:—

	1908. tons.	1909. tons.	1910. tons.
Gariajhor	13,942	43,877	41,958
Birbira	3,000	*Nil*	...
	16,942	43,877	41,958

Some 500 tons were despatched from the mines in 1908, whilst during 1909 58,000 tons of ore were railed to Calcutta, of which 31,460 tons were shipped during the year; during 1910 43,985 tons of ore were railed to Calcutta.[1]

Geology.

The two principal deposits are close together, Birbira (Kusummunda) lying only 3½ miles to the north-east of Gariajhor. This direction corresponds roughly with the strike of the Dharwar schists, with which the manganese-ores are associated, and which occupy the whole of the ground between Gariajhor mine and Dharuadihi (except where they are obscured by soil and laterite, itself often manganiferous). These Dharwars comprise mica-schists, mica-phyllites, quartzites, and grey dolomites, the latter being exposed at the crossing of the Sampai river.

Interbedded with the schists and quartzites are found the manganese-ores, in many places (especially in Birbira) with associated manganese-silicate-rocks, amongst which the following varieties, many of them indistinguishable from members of the gondite series in the Central Provinces, have been noted:—Ordinary fine-grained gondite, coarse-grained varieties of the same rock, spessartite-rock, and spessartite-barytes-rhodonite-rock; any of these rocks may contain braunite as well.

It is unnecessary to discuss here the origin of the Gangpur ores, for the available evidence indicates an origin similar to that of the manganese-ore deposits associated with the gondite series in the Central Provinces (see pages 364 and 365 of the Memoir already cited).

Manganese-ores have been found at several spots along the S.W.-N.E. line connecting Gariajhor and Kusummunda; they may be grouped under two headings, as follows:—

List of Deposits.

1. Gariajhor (with Kendmal).
2. Birbira (with Kusummunda).

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[1] Figures kindly supplied by Mr. Shrager.

It is said that ores have also been found further to the N. E. of Kusummunda, along the continuation of this line of strike.

Nature of the ores.

The ores found in the Gangpur deposits are principally psilomelane and braunite, mixed in various proportions, the braunite showing different degrees of coarseness; many of these ores are indistinguishable by eye from those of the Central Provinces. Many of the specimens collected—especially some dirty, friable ores—are, however, strongly magnetic, the strength of magnetism being much greater than could be attributed to the feeble magnetism usually shown by braunite, the specimens suggesting in one case vredenburgite, and in others manganmagnetite; but, in the absence of quantitative analyses, these minerals cannot be named definitely.

Quality of the ores.

Below I give some analyses both of hand-specimens, and of large samples, kindly supplied by Messrs. I. Shrager and G. M. Prichard :—

Five hand-specimens of Gariajhor ores analysed by Messrs. Pattinson and Stead.

	1	2	3	4	5
Manganese . . .	55·35	58·64	55·84	45·48	50·71
Iron . . .	3·60	1·70	1·98	16·33	4·15
Silica . . .	3·03	1·18	0·90	0·65	2·10
Phosphorus . .	0·089	0·079	0·132	0·141	0·110

I was able to examine the hand-specimens corresponding to these. The mineral composition of each is given below :—

No. 1.—Banded, slabby, hard braunite-psilomelane ore, very fine-grained.

No. 2.—Rather coarse-grained, hard braunite-psilomelane ore.

No. 3.—Banded braunite-psilomelane ore with the psilomelane predominant, and a large number of tiny black specks making the ore somewhat vesicular.

No. 4.—Soft crystalline ore, with some of the hard grey braunite-psilomelane ore in the middle.

No. 5.—Concentric-banded psilomelane (lead-like), with soft black ore.

A bulk sample of about 200 tons of Gariajhor ore at Dharuadihi station, assayed by Mr. Prichard, gave—

Manganese	51·81
Iron	6·38
Silica	3·52
Phosphorus	0·09

The following analyses of Kusummunda (Birbira) ores were also made by Mr. Prichard:—

Four Samples of Kusummunda (Birbira) ores.

	1	2	3	4
Manganese	49·44	50·03	50·80	45·34
Silica	10·65	...	...	11·75
Phosphorus	0·068	0·011	0·057	0·078

No. 1.—545 tons of ore, since shipped.
No. 2.—Same as No. 1 after picking at the railway station.
No. 3.—About 40 tons of stacked 'boulder' ore.
No. 4.—6 stacks of bed ore south of No. 1 hill.

Mr. Shrager has supplied me with the results of analysis of 30,710 tons of ore shipped during 1909, the number of separate cargoes being 53. The results are summarised below:—

Range and Mean of Analyses of 53 cargoes of Gangpur Manganese-ore (30,710 tons).

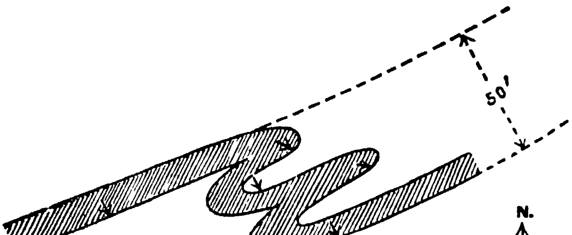
	Range.	Mean.
Manganese	45·58 to 54·13	49·31
Iron (54 analyses)	2·60 to 7·92	6·59
Silica	2·60 to 11·20	4·41
Phosphorus (51 analyses)	0·061 to 0·150	0·117

1. Gariajhor.

Under this heading are included seven exposures of manganese-ore or associated manganese-silicate-rock. They extend along a general

N.E. to E.N.E. line for a distance of about 1,400 yards. The four south-westerly exposures are in Kendmal *mauza* (village area) and the other three in Gariajhor. The most important of them is the most south-westerly of the Gariajhor occurrences, which is also the most valuable of all the Gangpur deposits at present known.

It gives rise to a low ridge (Gariajhor Hill, say 70 to 80 feet above the surrounding low ground), towards the east end, and gradually decreases in height towards the S.W., until finally it runs into Kendmal *mauza*. Manganese-ore has been exposed for a distance of 720 feet along this ridge. The evidence obtainable in the workings at the time of my visit indicated that the ore-band is not one of great thickness—about 10 to 20 feet was the maximum that was exposed at various points—, but that it has been much folded and doubled on itself in Gariajhor Hill, so that the effective thickness of ore at that point is apparently 50 feet or more. This is indicated diagrammatically in the figure. Further there were indications that the ore-band after being thus folded, doubled back on itself and continued to the W.S.W.; yet it seemed more probable, in view of the existence of the second Gariajhor outcrop some 560 yards to the E.N.E. that the ore-band finally continued in that direction, as is indicated in the accompanying figure. Subsequent excavation has proved this to be the case.[1]



Rough diagram representing the folding of the ore-band in Gariajhor Hill.

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[1] Mr. Vredenburg, who has recently visited Gariajhor (November 1910) informs me that the deepening of the excavation has revealed the existence of a second band of ore roughly parallel to the one originally seen and situated to the south of it at a distance varying from 50 to 100 feet. It has an average thickness of 15 feet. The quality and constitution of the ore is the same as in the ore-body described above.

The hill probably owes its existence to the folding of the ore-band giving a greater effective thickness of the hard resistant manganese-ore than is found in other parts of the deposit.

The general strike of the ore-band is E.N.E. and the general dip 30° to 45° to the S.S.E.; but the folding gives rise to many exceptions. The *country* consists of interbanded mica-phyllites and quartzites, the latter being frequently interlaminated with the ore-band. The quartzite, when fresh, is a reddish to greyish, fine-grained, vitreous rock, weathering to a soft white powder. Often it is impregnated and partly replaced by manganese oxide, and then it is usually black in colour. In places the quartzite is very micaceous and soft. Another constituent of the *country* in places is a very friable white felspathic schist.

Minerals in the deposit.

The manganese-ore has a bedded structure, and consists typically of layers of the hard grey mixture of braunite and psilomelane, of wad, and of the dirty friable magnetic ores. Frequently, it has cavernous spaces along the bedding planes in which soft pyrolusite, and also concretionary forms of psilomelane, tend to develop. Small veinlets ($\frac{1}{32}$ to $\frac{1}{4}$ inch thick) cut across the ore in places, and are sometimes open in the middle, with the walls lined with psilomelane.

In one place I saw some remains of spessartite in the wad-like ore next to the soft white footwall of the deposit; whilst Dr. A. W. G. Bleeck obtained some good crystals of spessartite, also from the footwall side of the deposit. These crystals are of clove-brown colour, up to $1\frac{1}{3}$ cm. in diameter, and are simple trapezohedra. Dr. Bleeck also found some good crystals of braunite (up to 0·8 cm. in diameter) at the same spot, showing the following faces; *c, p, x,* and *a* (*vide infra,* page 44). These specimens are now in the Geological Survey collection. On the ore-stacks I found one good specimen showing numerous spessartite trapezohedra up to 0·8 cm. in diameter, and one specimen of manganese-ore showing some bronze-coloured mica.

The working of the deposit.

The deposit is being worked by the customary open cast methods. The waste is dumped on the N.W. side of the ore-ridge. The ore is run out on rails supported on trestles to the S.E. side of the deposit and tipped out on to a dumping ground close to the terminus of the tramway. The tramway is of 2-foot gauge, about 7 miles in length, and is built of 20-lb. rails with wooden sleepers. The Sampai River is crossed by a temporary bridge made of timber cribs. In addition to this, there are three smaller permanent bridges. The steel wagons have a capacity of 3 tons. The engines are 40 H. P. Up to 450 tons of ore a day has been railed over this line.

Kendmal.

Three of the four Kendmal workings are on low hillocks a little to the west of the south-western end of the Gariajhor main deposit, and to the N.W. of its line of strike; but the relationship of the ore exposed in them to that of Gariajhor Hill cannot be stated until the intervening ground has been opened up.

The fourth Kendmal working is about 1,100 feet S.W. of the west end of the Gariajhor main band, and is probably a continuation of it. The exposure is 160 feet long and has been partly opened up. Some 6 feet of ore and black manganiferous quartzite overlain by mica-phyllite was exposed in a small excavation, but the full thickness of ore was not visible. The dip is 45° to S. 35° E.

Gariajhor North-East Workings.

The second of the Gariajhor workings is situated about 1,600 feet E.N.E. of the east end of Gariajhor Hill, east of the south end of a small tank. It is an outcrop of typical fine-grained gondite or spessartite-rock, indistinguishable both macroscopically and microscopically from similar rocks collected in the Central Provinces.

There is another outcrop on a low bushy ridge some 600 feet N.N.E. of the foregoing and close to the north end of the tank already mentioned. A trench across the N.E. end of the ridge shows 4 feet of thick-bedded manganiferous quartzites with some manganese-ore (psilomelane) of good quality. The quartzites have been rendered manganiferous by secondary replacement. The dip is to the E. 35° S. at 30°, curling over to horizontal at the N.W. end of the trench. The associated rocks are sericitoid phyllites and schists, with quartzites. A stack of some 36 tons of ore, similar in mineral constitution to that of Gariajhor Hill, had been extracted here.

2. Birbira (Kusummunda).

This name is given to a series of outcrops, scattered along a line running about N.E. to N.N.E. in the lands of the zemindar of Birbira, a village on the Usthali Nala. The chief occurrence is that lying farthest to the north-east, and situated some 3 miles N.E. of Gariajhor Hill, and about 3½ miles S.E. of Satparlia H. S. (1,341 feet), within the bounds of a small village called Kusummunda. Between it and Gariajhor are the other occurrences of manganese-ores and rocks also included under Birbira.

The chief outcrop, on which a considerable amount of irregular excavation has been done, shows a series of phyllitic schists with subordinate quartzites, and thin bands of gondite. The quartzites are often manganiferous, due to impregnation and replacement; and sometimes the replacement has proceeded far enough for the product to be called manganese-ore. The gonditic rocks, also, are often converted to ore. None of the ore looks primary, however, and nowhere did I see it in quantity. The beds seem to be rolling in places, and in others to dip at angles as high as 10° to 20° in south-easterly directions. Both from *in situ* and from the dumps I collected several specimens of gondite. In coarse-grained specimens the garnet is bright orange, sometimes showing the trapezohedral faces so characteristic of spessartite.

Rhodonite and barytes.

Some 300 yards south by east of the main set of workings is a prominent hillock about 50 feet high, running for some 80 yards in a S.S.W. direction. It shows large blocks of banded gondite and quartzite, often manganiferous. The dip is moderate to the W.S.W. At the southern end of the hillock a S.E. strike-trench discloses gondite and manganese-ore. From one of the extracted blocks I obtained specimens of spessartite-barytes-rhodonite-rock, in one case with braunite and copper-coloured mica as well. This also is very similar to some of the rhodonite-barytes-bearing members of the gondite series in the Central Provinces, *e.g.* at Chargaon.

II. THE DISTRIBUTION OF THE GONDITE SERIES IN INDIA.

From the foregoing we see that the manganese-ore deposits of Gangpur State contain (1) manganese-silicate-rocks indistinguishable from some of the members of the gondite series of the Central Provinces (see page 18): and (2) mixed ores of braunite and psilomelane typical of the deposits of the same province; (3) further, the deposits are associated with a country of schists and quartzites indistinguishable from some of the rocks found in association with the manganese-ores and gonditic rocks of the Central Provinces. Taking into consideration all these points, there can be no reasonable doubt that the manganese-silicate-rocks of Gangpur belong to the group of rocks known in the Central Provinces as the gondite series. This term can therefore be extended to Gangpur.

Now Gangpur is nearly 250 miles east of the most easterly occurrence of the gondite series previously known, namely, Ukua in the Balaghat district. This series of manganese-silicate rocks is, therefore, now known to occur over a total distance of nearly 700 miles, measuring along a west to east line from Jothvad in the Narukot State, Bombay Presidency, and Jhabua in Central India (the *western area*) through Chhindwara, Nagpur, Seoni, Bhandara, and Balaghat, in the Central Provinces (the *central area*), to Gangpur in western Bengal (the *eastern area*). The occurrences fall into the three groups indicated in brackets, of which the western area is separated by about 300 miles from the western end of the central area, which is about 110 miles long; whilst the eastern end of the central area is separated by nearly 250 miles from the eastern area in Gangpur.

The gap between the western and central areas can never be filled, because the larger portion of this ground is covered by lavas of the Deccan Trap formation; nevertheless, it is not at all improbable that gonditic rocks do exist beneath the Trap. It is quite different with the gap between the central and eastern areas of the gondite series, which coincides with the Chhatisgarh division of the Central Provinces. For in Dr. King's map of the Chhatisgarh basin [*Rec., G. S. I.*, XVIII, (1885)] Chilpi Ghat beds—the local equivalent of the Dharwars—are shown covering a considerable area at the western end of the basin; in addition, it is possible that portions of the areas tinted pink in this map to indicate 'crystallines' may contain some highly metamorphosed portions of the Dharwars. Hence it is not unreasonable to expect that members of the gondite series, possibly with associated manganese-ores, may be found in the future in parts of this division, particularly in the Bilaspur and Drug districts, and Raigarh, and with less probability in the Raipur district; and also, not improbably, in the northern parts of the Sambalpur district in Bengal, immediately adjoining Gangpur on its southern boundary. In this connection it is interesting to draw attention to the discovery of manganese-ore at two localities in the Bilaspur district, although, as far as is at present known, they are of no economic value and occur in a very slightly metamorphosed facies of the Chilpi beds [see *Rec., G. S. I.*, XL, p. 334 (1910)].

In addition to the districts and States mentioned above, rocks of the gondite series probably occur in Banswara State in Rajputana, lying immediately to the north of Jhabua State. Moreover, it would not be surprising if such rocks were found still further north, in the Aravalli Hills.

THE BALUCHISTAN EARTHQUAKE OF THE 21st OCTOBER 1909. By A. M. HERON, B.Sc., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 4 and 5.)

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1. INTRODUCTION.

AS might be expected in a region of folded mountains of comparatively recent or still continuing uplift, Baluchistan is from time to time visited by earthquakes of greater or less severity. Of those recorded the most important in its topographic effects was that of Sanzal on the 20th December 1892,[1] though exceeded in its destruction of life by the subject of the present account.

Locality.

The Kachhi plain, the locality of this earthquake, is a bay of alluvium (*pat*) enclosed on three sides by the great flexure of the ranges between the Bugti and Kirthar hills. The railway line between Jacobabad and Sibi traverses this from south to north, crossed at an angle of about 40° by the elongated oval of the epicentral tract.

Method of investigation.

Unfortunately only two earthquake forms were received (from the Meteorological observers at Quetta and Jacobabad) and five weeks had elapsed before I was able to visit the scene of the calamity, during which time a considerable amount of excavation among the ruins, and even rebuilding, had been done. Outside Baluchistan and the immediately contiguous portion of Sind the shock does not seem to have been felt. My cordial thanks are due to Sir Henry McMahon and Major Jacob of the Baluchistan Government, Mr. H. C. Dobbs and Mr. A. N. L. Cater of the Sibi Agency, Major McConaghey of the Kelat Agency and Mr. W. Beechey, Executive Engineer of the North Western Railway, for much information and assistance.

The data for the present account, apart from those given by the above gentleman, were collected during a fortnight's tour over the area in which damage had been done, an attempt being made to visit and examine every village in it.

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[1] Griesbach, *Rec. Geol. Surv. Ind.*, XXVI, p. 57; McMahon, *Q. J. G. S.*, p. 291, (1879); McMahon, *Geog. Journal*, IX, p. 402, (1897).

Owing to the scattered distribution of the population and their comparatively uneducated character, and above all to the total absence of Europeans from the damaged tract, verbal information of the type usually asked for on earthquake forms was found to be of little use, and personal observation of actual wrecking was practically entirely relied on.

In the hilly tract surrounding the Kachhi plain, no attempt was made to collect information or draw isoseismals (except in the southern part of the Bugti hills east of Shahpur), as here the population is still scantier and less civilised, and small earthquakes are of such frequent occurrence as to call for little notice from the inhabitants. In the hills no damage was done to property and the shock passed almost unnoticed except in Quetta. No reports were received from any seismological stations.

2. GENERAL ACCOUNT OF THE SHOCK.

Time.

Three time observations are available. The Meteorological Observers at Quetta and Jacobabad both give 5-12 A.M. as the time of the shock, while the Bellpat station clock stopped at 5-7 A.M. The distances of these places from Bellpat, the epicentre, are respectively 96 and 56 miles, giving velocities for the vibrations of 0·32 and 0·19 miles per second, which are much too low, the average for the Kangra earthquake of the 4th April 1905, being 1·92 miles per second,[1] and for the Assam earthquake of the 12th June 1897, 1·98 miles per second.[2]

Rate of transit of vibrations.

Obviously, then, the Bellpat time is unreliable, and the concordance, real or spurious, of the other two times deprives us of any means of estimating the velocity of propagation. At this early hour most of the victims and survivors were asleep, but those who were awake, on railway duty or for other reasons, unite in testifying to the suddenness of the shock, a feature common to most large earthquakes.

As one of the intelligent Saiyads of Shahpur remarked, 'There was hardly time to raise ourselves on our elbows before the roofs began to fall.' In cases where houses collapsed, none of the inmates seem to have had time to effect an exit before the roofs began to give, and escapes were due to protection by beams and to the fact that the roofs and walls often fell in sections.

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[1] Middlemiss, *Mem. Geol. Surv. Ind.*, XXXVIII, p. 291.

[2] Oldham, *op. cit.*, XXIX, p. 70.

Number of shocks and duration of vibrations.

Regarding the number of shocks and the duration of the vibrations there is considerable diversity of testimony. Sir Henry McMahon, at Quetta, considers that two distinct shocks occurred, the vibrations being continuous between and lasting altogether about 45 seconds. With this opinion Major Jacob and Major McConaghey agree, while the Meteorological Observer mentions one shock only, of 10 to 15 seconds' duration.

In Sibi three shocks were felt, but the duration is given by several Indian observers as three or four minutes, and at Mittri five to six minutes! At Jacobabad the Meteorological Observer detected three shocks, the first lasting 40 seconds, the second and third (probably aftershocks, as he mentions two times, 5-12 A.M. and 6 A.M.) very slight.

The sound.

Regarding sound, there is a still greater difference of opinion, due in part to the lesser sensitiveness compared with Europeans, of many Indians to sounds of very low note, and to the obscuring din from local causes, such as slamming of doors, cracking of roofs, etc.

It is variously described as 'sound as if hundreds of persons running with shoes fast over roof,' 'cracking sound,' 'like guns,' and many witnesses are positive that they heard no warning sound. However, preceding several of the aftershocks a noise like the distant report of a single cannon (without reverberations) is said to have been heard, and while I was in Shahpur I heard three such, coming from the uninhabited desert to the N.W. of Shahpur, one of which at least was followed by slight vibration lasting for three seconds. The other two happened while I was on a riding camel, a situation in which an earthquake of considerable severity might pass unremarked. We may fairly conclude therefore that in the epicentral tract and its immediate neighbourhood the shock was preceded by a sound of low note, like the report of a heavy gun.

Aftershocks.

Anything approaching a complete record of aftershocks is naturally impossible in the absence of competent observers, but a certain amount of information has been collected from Bellpat, showing that for the period from the 21st October to the 31st, 76 shocks were noticed, and from the 1st November to the

14th, 14. In one of these, at 2-30 A.M. on the 1st November, a woman was killed at Jalal Khan, a village 18 miles from Bellpat and well outside the epicentral tract. In Bagh and Shahpur, up to the time of my visit early in December, tremors were of almost daily occurrence, and often took place three or four times a day, as described above. A number of shocks have been reported from other villages, decreasing in number as we pass outwards from the centre of disturbance until we reach regions (in the hills) where it is doubtful if they have any connection with the Kachhi earthquake, but in all probability arise from independent strains. In the epicentral tract aftershocks were felt with diminishing frequency up to April 1910, the latest date of which I have information.

3. THE ISOSEISTS.

On the accompanying map are shown the three isoseists which I have considered it advisable to insert without putting too great a strain on the data.

Intensity scale used.

In these curves the Rossi-Forel scale of intensity has been adopted in preference to the Omori scale, as being more suitable for an earthquake of moderate intensity than the latter, the higher grades of which include surface intensities much in excess of that met with in the present case. In using the Rossi-Forel scale an allowance has to be made for the difference between the massive but weak local buildings and the more substantial stone and lime structures for which the scale was designed.

Construction of buildings.

In the area examined stone buildings are unknown, and lime mortar is infrequently used. In the smaller villages, inhabited mainly by agriculturists, and in the meaner portions of the large villages the houses, one-storeyed as a rule, have their walls of mud (*gam*), built together in a pasty state, or of flat sun-dried bricks (*sil*), set in mud as a cement.

The roofs are of branches, with or without a layer of mud, or of wooden beams carrying reeds or matting, on which is laid mud some six inches thick. In the larger villages there are numerous mosques and two or three-storeyed houses belonging to zamindars and prosperous traders. These are constructed of burnt or sun-dried brick in mud mortar, plastered on the faces of the walls with mud and having very heavy roofs of mud on reeds and rafters. Walls of compounds are generally of simple mud. The railway buildings are a most heterogeneous assortment of styles, but are all one-storeyed. Perhaps the most usual is of burnt brick walls laid in mud or lime mortar of poor quality, the roofs having old rails or wooden beams as rafters, on which lie thick brick tiles covered with mud on the outside. Reeds are sometimes used instead of tiles. Variations on these methods of building are sun-dried brick walls, corrugated iron roofs or roofs of sleepers laid close together, and huts constructed of a framework of sleepers or rails in which are built up panels of sun-dried brick or mud. For certain temporary huts about railway stations, and also here and there in villages, *sirki*, *i.e.*, screens of matting with or without mud plaster, have been used.

Intensity of the shocks.

It is evident from the absence of the slightest damage to the permanent way of the railway, or fissuring of the earth's crust (apart from gravitational slips of alluvium), that the maximum intensity of the shock was not so great as X of the Rossi-Forel scale. The next grade, IX 'partial or total destruction of some buildings,' seems to fit the case of the epicentral tract fairly well, if we admit that the comparatively incoherent and inelastic walls of the local buildings, coupled with unusually heavy roofs, have increased the effects to the total destruction of all but one-storeyed buildings. Outside this, in the area between isoseists IX and VIII ('fall of chimneys, cracks in walls of buildings'), practically all walls have been cracked, numerous parapets and isolated walls have fallen and a few roofs of poor construction have collapsed. In India, damage to buildings is considered to begin at grade VII,[1] and within this zone falls of plaster and cracks in buildings are numerous, without really serious damage having been done.

In any case an intensity scale founded on such variable factors as damage to buildings is at the best an empirical approximation, in which any modifications tending to uniformity of standard are preferable to a strict adherence to details.

Isoseist IX.

As shown on the map, this curve is an elongated oval, in area about 450 square miles, with its longer axis running in a N.W.-S.E.

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[1] Middlemiss, *Mem. Geol. Surv. Ind.*, XXXVIII, p. 302.

direction. It embraces the two large villages of Bagh and Shahpur, the railway station of Bellpat and several small villages.

Railway undamaged.

Perhaps the most striking fact to note is that the railway line traversing the area was absolutely undamaged, as were also the telegraph line and the iron water-tanks carried on tall rail frames. In the latter case there was no sign of vibration, even where the rail columns were bedded into brickwork foundations.

Bellpat.

In striking contrast is the havoc wrought to the station buildings and bazar of Bellpat, to which the mortality, 26 out of a total population of 235, is sufficient testimony. It is noteworthy that 25 of these deaths were in the station buildings, one only in the bazar, a convincing proof that in point of safety the low mud huts of the latter, with mud on matting or branches as roofs, were much preferable to the better built, but really incoherent, Government buildings. In the bazar every house was damaged, but many were still habitable and, so far as I could judge, most of the havoc had been caused by the infalling of roofs, carrying with them walls, or parts of walls, rather than by the original collapse of the walls themselves. In the railway station the only buildings left standing were the outhouses of the Rest House and one block of employés' quarters (built last year). These were of burnt brick, as was also the office on the platform, which however had lost its roof. All other buildings, of whatever construction, were wrecked, only a wall here and there being left.

Direction of falling.

Regarding the direction in which buildings fell, no general rule could be established. At the time of my visit wreckage had been largely cleared up, unsafe walls demolished and old materials collected preparatory to rebuilding. The evidence of eye-witnesses of the collapse is most conflicting and nothing definite can be deduced.

Bagh.

Passing now to Bagh, as the north-west extremity of the epicentral tract, we have to consider a village of quite a different type. It is much larger than Bellpat having a population variously estimated at from 1,500 to 3,000 (I should say more probably the latter), and had numerous mosques and fine two-storeyed buildings. These are constructed of both sun-dried and burnt brick of the local tile shape, and the smaller huts are of mud. The usual roofs are of mud laid on matting, or in the better houses, of mud on reeds, in both cases of course supported by heavy beams. The Tahsil and one or two new houses and a few mud huts are all that remain unwrecked, and they also are much cracked.

Resisting power of materials.

There seems to be no appreciable difference in the resisting power of raw and burnt brick, but mud huts have stood better, when kept in good repair, a circumstance due probably to their lesser height and greater homogeneity. No system was observed in the direction of cracking or the way in which houses had fallen; the whole seems to have collapsed like a house of cards.

Excessive mortality among Hindus.

Though the proportion of Mahomedan inhabitants to Hindus was two to one, the respective deaths in these sections of the community were 29 and 37, giving a mortality rate for the Hindus two and a half times that for the Mahomedans. This is attributable to two causes, the first that Hindus are said to sleep indoors more than Mahomedans and so have less chance of escape; the second that the Hindus are mainly of the *bania* (shopkeeper) caste and are therefore in general more prosperous than their Mahomedan neighbours and can better afford two-storeyed houses; these suffered more severely.

Shahpur.

Shahpur, a village of about the same size as Bagh, near the other (S.E.) end of the epicentral tract, presented an aspect of melancholy desolation. I am told that before the earthquake, its tall houses and splendid mosque were visible for miles around. Now it is a heap of ruins, made still more forbidding by its situation among lifeless sandhills, in the hollows of which the inhabitants had pitched their miserable shelters of reeds and branches. Of its three hundred houses not one remains and even the thick clay walls of compounds have been levelled. The materials of the houses are mainly sun-dried brick and mud.

The same peculiarly high mortality among Hindus has occurred here. In a population about equally divided, 69 Hindus were killed as against 33 Mahomedans, a death rate approximately two to one.

Direction of falling.

At the time of my visit the ruins had been considerably disturbed by the villagers in their search for their valuables and their dead, so I personally could make few reliable observations of the direction in which objects had fallen; but I am credibly informed that when able to fall freely, the buildings had done so to the north-west, showing that the shock had come from somewhere in the direction of Bellpat.

Saiyad Hasan's tomb.

A very large tomb (Saiyad Hasan's), some five miles west of Shahpur, well built of burnt brick in plaster mortar and covered with glazed tiles, has fortunately suffered little. A good deal of the fine tile work has fallen, along with the pinnacles, but its sound construction has saved it from serious injury. The pinnacles fell towards the north, a direction consistent with the Shahpur observations.

Smaller villages.

The smaller villages of the epicentral area are situated mainly in the Nari, Lehri and Belab river tracts, and these, with the crossing-station buildings along the railway north and south of Bellpat, may be described generally. In these villages mosques as a rule are wrecked, being the highest buildings and built of brick. The houses, small huts with mud walls and roofs of branches, and mud, lighter than is customary in larger villages, are usually all damaged and one-fifth or more have fallen.

Muradwa.

At Muradwa, near the centre of the affected area, every house is wrecked and even shelters of brushwood have been thrown to the ground, the most violent manifestation of the shock met with.

The railway huts, mostly frames of sleepers filled in with brick or mud, were wrecked, while corrugated iron sheds were quite uninjured.

From these villages 20 deaths are recorded.

Slips of alluvium and surface cracks.

In most of the river-courses flowing through this area, small falls of soil have taken place from the steep, almost overhanging, banks. In the dry bed of the river above the tank at Bagh, water oozed up in several spots. It was very bitter and has left an efflorescence on the surface. Good water is said to lie at a depth of fifteen feet, with bitter water below it so the earthquake must have disturbed the lower stratum. Here the river runs north and south, with a shelving bank on the east side, which, from the top of the bank to near the bottom, has moved bodily downwards, covering to the extent of a foot or two some cultivation on the flat below. The slipping has given rise to two systems of cracks, one set running close together along a steepish part of the bank for some fifty yards, in a direction parallel to the river. They are about six inches wide and are numerous, forming a band of fracturing two or three yards wide. The other set are smaller and less numerous, not more than an inch wide, and run up the bank perpendicular to the main group. The plane of sliding has probably been moistened by the water exuded from below, facilitating motion. Farther downstream, where the shelving bank is found on the west side, the same thing is seen (Plate 4).

Around Shahpur are patches of clayey ground about the bases of the sandhills. These are seamed with zig-zag cracks, having a fairly persistent average trend of N. to N. 20° E., with branches and some cross-cracks. They are one or two feet apart, ⅛ inch to ¼ inch wide, and the vertical displacement, if any, is only ¼ inch and is not in any definite direction, as if the cakes of clay had been shaken about at random. The cracks are approximately parallel to the direction the seismic vibrations have probably taken.

Here also the falling of precipitous stream banks is general, and the hummocks of hardened and wind-sculptured argillaceous sand, so frequently found among drifting sand-hills, are cracked and broken in all directions. East of Shahpur, in the extreme south of the Bugti hills, is an expanse of hillocks of incoherent and obscurely stratified clay and gravel, mapped as Upper Siwaliks. Their steep and unstable slopes are scored by innumerable small surface slips.

Two small rock-falls took place on the railway line at the ends of the Nari Gorge tunnel, a locality falling within grade VI of the scale, and far outside the area of damage. The rock-slopes here are so extremely unstable that slips cannot be taken as evidence of any considerable disturbance.

No resemblance to a "fault-cliff" of even minute dimensions was seen, though nothing could be better adapted for its preservation than the hard and level surface of the 'pat' desert.

Isoseist VIII.

The area within the next isossist, grade VIII, is about 1,550 square miles, and its shape is almost exactly that of isoseist IX. In it there are no villages of the size of Bagh or Shahpur, but a fair number of smaller ones, several having good mosques and two-storeyed houses, which, as usual, have suffered more than the smaller buildings round them. As a rule in this tract few houses have actually collapsed. Here and there a roof or a gable has fallen, parapets and pinnacles of mosques have frequently gone, and cracking of walls is general.

Direction of cracking.

It was exceptional to be able to discern any general method in the way in which houses had cracked or objects had fallen, and, when it was possible, in only two cases out of three did this agree approximately with the local direction of vibration, assumed to be parallel to the isoseists. (Theoretically the direction of cracking should be parallel to the wave-front, and the direction of falling perpendicular to it.)

In this area also the most seriously damaged houses are the composite ones of sleepers and brick or mud, used as gang-huts and crossing-stations on the railway.

Katiar.

As an example of the variety of the degree of damage which may occur in a single village, take the case of Katiar, near the outer margin of this isoseismal area. A large three-domed mosque of burnt brick in mud mortar, almost completed by the Sirdar of the village, had lost two domes and was badly cracked. The top portion of a new and very high house of burnt brick had been shattered, and one of its gables had fallen. On the other hand, another fine mosque five years old was damaged only to the extent of a single pinnacle, and another high house, of raw brick, fifteen years old, was scarcely cracked. The small houses and walls in the village are practically uncracked.

Isoseist VII.

Within the next isoseist, grade VII, is included an area of 2,200 square miles, and its shape is the same as the two above described. Only a house here and there has been badly damaged, usually by a roof falling in or by the collapse of an arch. Mosques have occasionally lost their pinnacles and roof parapets have fallen, through the sagging of the roofs round which they are built. Cracking is by no means general, and has taken place in positions of weakness, such as the tops of arches and the junctions of walls.

Haji.

Haji, a large village at the north-west end of the area, has suffered with exceptional severity, for some local reason unexplained. Practically all the houses are cracked, and fifteen or sixteen have fallen, including the dome of the mosque. Seven people were killed. It is noticeable that corners and gables of houses on the northern side have suffered most. Outside this line evidence was but scanty and largely the testimony of untrained observers, but so far as it went showed a very gradual diminution of intensity.

4. THE FOCUS.

Origin in straight fault.

The most obvious feature of the epicentral tract is its great elongation in comparison with its width, betokening an origin from a straight line of faulting at no great depth and approximately vertical. There are some indications that the greatest intensity was to the north-west of Shahpur.

Depth of focus.

In finding the depth of the focus, the old method of intersection by drawing perpendiculars to the direction of the cracks in buildings, was found absolutely useless. The angles which the cracks made with the surface of the ground were found to be quite inconsistent and evidently depended more on slight inequalities of the buildings than on anything else.

In the method of Major C. E. Dutton, the depth of the focus is found by multiplying by $\sqrt{3}$ the distance from the assumed epicentrum to an empirical point where the intensity is considered to decrease most rapidly.

Two lines were fixed on, one between Lehri and Chachar, the other between Bellpat and Kokar, in the Lehri and Nari river tracts respectively, as in these, villages are frequent, comparatively speaking. On the first of these the required point seemed to be between 8 and 12 miles from the epicentre, giving a depth greater than 16 and less than 20 miles; in the second case, more than 6 and less than 9 miles from the epicentre, corresponding to a depth between 10 and 15 miles. For the Kangra earthquake Mr. Middlemiss calculates depths between 12 and 21 miles and between 21 and 40 miles. Comparing the areas included by the several isoseists in the Kangra and Baluchistan earthquakes, we are led to believe that the values given above for the depth of the latter's focus are probably as accurate as might be expected, but it must be admitted that outside isoseist VIII the intensity of the Baluchistan earthquake died out with very much greater rapidity than that of the Kangra shock, from which it would appear that my estimate is too large.

Isoseist.	Area contained by isoseists.	
	Kangra.	Baluchistan.
X.	200 sq. miles	...
IX.	1,600 sq. miles.	450 sq. miles.
VIII.	2,150 sq. miles.	1,550 sq. miles.
VII.		2,000 sq. miles.

5. INTENSITY; ACCELERATION OF WAVE PARTICLE.

Unfortunately no measurements could be made of the acceleration, amplitude, velocity, or period of the wave particle. The region affected was quite devoid of seismographs.

Observations of overturned or projected objects could not be made in the total absence of suitable cases. When pinnacles of mosques, walls or parapets had fallen, they had been smashed to fragments; had they been intact their intricate form and heterogeneous composition would probably have vitiated any results. Objects such as pillars or tombstones are unknown. Had I been on the spot earlier, the tall earthen urn-shaped grain-bins of the villagers might have yielded results, but these, when unbroken, had been re-erected.

6. EFFECT ON WATER SUPPLY.

The earthquake seems to have had little effect on subsoil water. At Kalandrani, a small village with three wells, near Shahpur, two of the wells had fallen in and the yield of the third was said to have become

It is reported that the 'Karez' water-supply of the Mustung valley has increased since the earthquake, but Mastung is so far from the point of origin, and the other effects of the shock were so slight there, that it is extremely doubtful if there is any connection between the phenomena. The uprising of water from the river bed at Bagh has been mentioned above.

7. GEOLOGICAL CONDITIONS IN RELATION TO THE EARTHQUAKE.

In a case like the present, where the earthquake area is so completely covered by thick alluvial deposits, any discussion of the cause must be little better than conjecture guided by probabilities.

A glance at the map suggests a relation to one of the most striking features of Indian geography, the gigantic festoon of the Marri and Bugti hills, by which the north and south trend of the Baluchistan ranges is interrupted, a feature which in its topography faithfully reflects the geological structure.

In a region of compression like this, so abrupt a flexure in the axes of folding must be the seat of special local stresses differing in character from the normal, and of a greater degree of severity.

Assuming that the epicentrum is a straight line, the trace of a fault running medially along the area of maximum disturbance, we see that towards its south-eastern extremity it is parallel to the nearest ranges there, and, therefore, in this case, parallel to the axes of folding.

Following it along to the north-west, we find that, if produced, it would meet the ranges between Dadar and Sanni at a high angle, about 80°. Thus it commences as a strike fault and continues as such until it is cut off by the abrupt southward sweep of the Kirthar range, or the strata parallel to the range, which no doubt flank it for some distance out under the alluvium.

The probability is that it is a reversed fault, since such faults more usually follow the strike than the dip, and since this is a region of compressive mountain elevation, in which thrusts predominate over normal faults.

8. THE EARTHQUAKE IN RELATION TO BUILDING METHODS AND MATERIALS.

At an early stage of the investigation it became evident that the main contributory cause of the great mortality, a total of 231, was the unusually heavy mud or tile roofs. The beams carrying these are built into incoherent, though thick, walls of mud, or what is even worse, bricks set in mud mortar. The inertia of the roof under oscillation had at once produced a line of division right round the walls at the point where the beams were inset, and the ensuing sagging of the roof showered down loosened tiles and cakes of clay on the interior.

As in all earthquakes, structures had suffered in proportion to their height.

No difference was observed in the resistive powers of sun-dried and burnt brick. Both these seemed to be inferior to simple mud, though comparison is difficult to institute, seeing that the latter is seldom used for any but one-storeyed houses. The fault of brickwork probably lies in the low quality and lack of tensile strength of the cementing material used and in the great temperature variations locally experienced, leading to disruption through expansion and contraction. Structures of burnt brick in lime mortar of decent quality stood well; still better were those of metal, for example, the water-tanks on the railway, and corrugated iron sheds. Where brick panel walls were used in combination with a metal or wood framework the results were disastrous.

Recommendations as to styles to be adopted in rebuilding are generally useless, save in the case of public bodies. Among Mahomedans an earthquake is regarded as an act of God, to guard against which savours of irreverence; by all classes it soon comes to be looked upon as a disagreeable experience unlikely to happen again, and in time custom and convenience overcome the dictates of prudence.

That houses should be one-storeyed is obvious.

Thick roofs are necessary as a protection against the heat of summer in this land, the hottest probably in all India. Still an endeavour might be made to use more thatching material and less mud or to have double roofs with an intermediate air-space. The roofs of heavy tiles adopted in many of the railway houses are most dangerous.

LIST OF PLATES.

PLATE 4.

Slip of alluvium on river-bank at Bagh.

PLATE 5.

Map shewing Isoseismals of the Baluchistan Earthquake of October 21st, 1909.

ON THE IDENTITY OF OSTREA PROMENSIS NOETLING FROM THE PEGU SYSTEM OF BURMA AND OSTREA DIGITALINA EICHWALD FROM THE MIOCENE OF EUROPE. BY E. W. VREDENBURG, A.R.S.M., A.R.C.S., F.G.S., *Superintendent, Geological Survey of India.* (With Plate 6.)

IN a previous note (*Rec., G. S. I.*, Vol. XXXVIII, p. 128) reference was made to Mr. H. I. Davies' remarkable discovery, in the Pegu system of Burma, of a fossil which, on examination, proved to be identical with *Ostrea latimarginata*, a particularly characteristic zone fossil of the uppermost Gáj beds of western India. Mr. Davies' discovery is a particularly valuable one from a stratigraphical point of view, as the occurrence of the fossil towards the upper limit of the Prome beds (the term being used as defined originally by Theobald) furnishes a useful datum line for correlating the subdivisions of the Pegu system with the palæontological zones recognised in western India.

Another *Ostrea* which principally characterises beds newer than the Gáj in the Mekran province of Balúchistán, *Ostrea Virleti*, Deshayes, also occurs in the Pegu system of Burma, where it has been described under the name *O. peguensis* Noetling. Unfortunately the exact horizon from which this fossil was obtained has not been recorded.

On comparing some of the Mekran fossils with the specimens from the Pegu system it has been found that there is yet one more form of the same genus which turns out to be identical in both regions. This is the fossil described by Noetling as *Ostrea promensis* which, on careful consideration, is undistinguishable from the Egyptian and Persian fossil already determined by Fuchs as *Ostrea digitalina* var. *Rholfsii*. The identity of the two forms would scarcely be suspected from the illustrations of *Ostrea promensis* in the *Palæontologia Indica*, (Fauna of the Miocene beds of Burma, *Pal. Ind*, N. S., Vol. I, part 3, 1901), which do not give a very exact idea of the specimens; figure 3, plate II, in particular, is a fanciful restoration of a specimen in which the ribs are partly obliterated by erosion, partly concealed by the sandy matrix. All the Burmese specimens are in a much more worn condition than the Mekran ones whose identity with *Ostrea digitalina* leaves no room for hesitation; but, on directly comparing a large series of specimens it is easy to ascertain that they are identical in every respect.

Ostrea digitalina and *Ostrea Virleti* were both originally described from the Miocene of Eastern Europe, *O. digitalina* from Volhynia, and *O. Virleti* from the Peloponnesus. Both species occur together in the Miocene of Egypt and of Persia. The same association is observed in Mekran where both species have been obtained in one bed. In the case of the Burmese specimens collected by Theobald and described by Noetling, the exact mode of occurrence of both species is unfortunately unknown: neither of them has been traced to a definite stratigraphical horizon, though they have almost certainly been obtained from the same zone at the same locality.[1] Latterly, Mr. Murray Stuart has discovered numerous specimens of *O. digitalina* in the sandstones overlying the Kama clay in the Henzada district. They are accompanied by other forms referred by Mr. Stuart to *O. crassissima* Lam. and *O. gingensis* Schloth., both of them common Miocene fossils in Europe, but *O. Virleti* has not been re-discovered.

According to Fuchs, the beds of the Siah Koh near Teheran that have yielded *Ostrea Virleti* and *Ostrea digitalina*, are regarded, on the strength of their fossil contents, as the approximate equivalents of the Schio and Loibersdorf horizons, and belong therefore to the Upper Aquitanian or to the passage zone from Aquitanian to Burdigalian. The Mekran specimens belong to a horizon that seems slightly newer than the uppermost Gáj. The bulk of the Gáj beds, by reason of the large lepidocyclines (group of *L. marginata*) which they contain, convey distinctly the impression of an Upper Aquitanian age. The Mekran beds with *Ostrea Virleti* and *Ostrea digitalina* (lower Hinglaj) would then be not newer than Lower Burdigalian, a result which agrees sufficiently closely with the conclusions derived from a study of the Persian fossils. The Egyptian occurrences of *Ostrea Virleti* and *Ostrea digitalina* belong, according to Fuchs, to a somewhat later age, and correspond with the Grund horizon, slightly newer, therefore, than the Burdigalian. The "Kama clay" of Burma corresponds in age with the Lower Hinglaj of Baluchistan. The overlying sandstones in which Mr. Stuart discovered specimens of *O. digitalina*, may be therefore slightly newer than those in which I collected the same species in the Mekran, and may correspond in age with the Grund horizon of Europe. From stratigraphical reasons, Mr. Stuart is of opinion that the beds that yielded the specimens discovered by Theobald in the Pegu Yoma are approximately on the same horizon as the strata containing the same species in the Henzada district.

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[1] Noetling's statement (*Fauna of the Miocene beds of Burma*, p. 108) that the matrix adhering to the specimens of *O. Virleti* (*O. peguensis* Noetl.) differs from that of *O. digitalina* (*O. promensis* Noetling) is scarcely accurate. In some instances the sandstone adhering to the specimens of *O. digitalina* has an ochreous colour, probably the result of superficial weathering The same ochreous material also adheres to some of the specimens of *O. Virleti*. The majority of the specimens of both species show a fine greenish-grey mica-spangled sandy matrix, crowded with fragments of shells. The mode of fossilisation in both species is identical. The locality of *O. digitalina*, not recorded in Noetling's monograph, is stated on a label in Theobald's hand-writing. There is no label with the specimens of *O. Virleti*.

The following description is based upon the material at present available in the Calcutta collection :—

Ostrea Digitalina, Eichwald, var. **Rholfsii,** Fuchs.

Pl. 6, figs. 1 to 4.

1879. *O. Rholfsii* . .	. Fuchs, Ueber die von Dr. E. Tietze aus Persien. mitgebrachten Tertiärversteinerungen.—*Denk. d. k. Akad. d. W., math. naturw.* Classe, Vol. XLI, part 2, p. 106, Pl. VI, figs. 5-8.
1883. *O. digitalina* .	. var. *Rholfsii*, Fuchs, Beiträge zur Kenntniss der Miocænfauna Aegyptens und der libyschen Wüste. *Palæontographica*, Vol. XXX, p. 44, Pl. XII, figs. 3-6, p. 61, Pl. XXII, figs. 1-3.

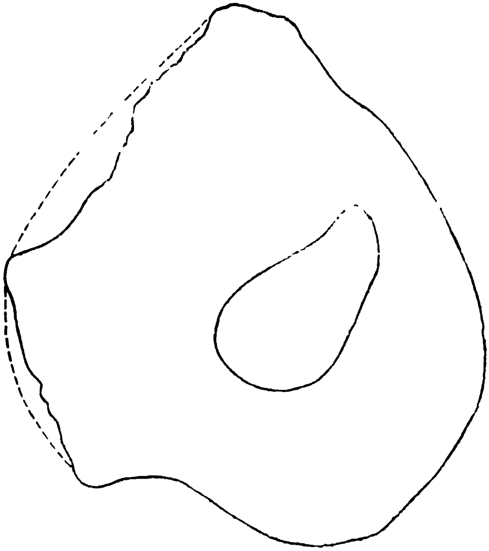
1901. *O. promensis* .	. Noetling, Fauna of the Miocene beds of Burma, *Pal. Ind.*, N. S., Vol. I, part 3, p. 109, Pl. II, fig. 3, a-b, Pl. III, figs. 1, a-b, 2, a-b.
non O. digitalina . .	. Mayer-Eymar, 1883. Die Versteinerungen der tertiaeren Schichten von der westlichen Insel im Birket-el-Qurun. See p. 74, *Palæontographica*, Vol. XXX. (This is shown by Oppenheim to be *O. Stanleyi*, M.-E, Zur Kenntniss alttertiärer Fauna in Aegypten, Part 1, *Palæontographica*, XXX, 3rd part, p. 24, 1903.)

The shape of the lower valve is orbicular or oval to crescentic, moderately convex. When the specimens are oval, the elongation is along the vertical direction. The largest of the Mekran specimens measures 70 × 70 mm. The largest of the Burmese specimens measures 90 mm. in vertical dimension and 70 mm. transversely.

The ribs are very pronounced, angular, fairly numerous. The ligament groove, generally deflected backwards, is much wider than the rather prominent swellings bordering it. The pallial groove bears very distinct punctations in the neighbourhood of the hinge in the Mekran specimens (see fig. 1, Pl. 6). Amongst the numerous Burmese specimens, this character varies, being very pronounced in some, obsolete in others.

All the complete detached lower valves have their interior obscured by the matrix so that it is not possible to make out the characters of the muscular impression. A fragmentary specimen illustrated in fig. 1, Plate 6, shows the edge of the muscular scar indicating for it a sub-central position.

The upper valve, much flatter than the fixed valve, is orbicular to crescentic. The portion nearest the umbo is swollen and frequently exogyroid. The ornamentation consists of concentric lines of growth. One of the specimens from Burma shows a rather large, shallow, sub-central muscular impression, the exact shape of which is rather obscured by the matrix. In all the other specimens the internal characters are concealed either owing to a strongly adhering sandstone matrix or because the two valves are still united in their original position. In one of the specimens from the Mekran which has lost its upper valve, there remains a cast of the inner surface of the valve, with a very distinct impression of the shallow muscle scar upon the indurated sand filling the body chamber. The outline of this cast is shown on the following woodcut which has been reversed to show the scar in the natural position it would occupy in the interior of the upper valve. It will be noticed that its position is sub-central and its disposition very oblique.



OSTREA DIGITALINA.

Inner cast of upper valve (inverted) showing position of muscular impression.

In all the above characters these specimens agree exactly with *Ostrea digitalina* Eichwald. The rather numerous and prominent ribs indicate that they belong to the variety *Rholfsii* Fuchs.

Geographical and geological distribution.—The specimens in the Geological Museum have been obtained from the following localities:

North of the Talar gorge, on the road from Kej to Gwadar; base of the sandstones constituting the Talar mountains, Mekran province, Balúchistán, Hinglaj series (Burdigalian). Coll. Vredenburg, G.S.I., No. K. 11-253.

Khayu Chaung (stream) between the Pazwundaung chaung and the Kenbati chaung; southern Pegu Yoma, Burma. Coll. Theobald.

The geological horizon of these specimens is unknown. They are embedded in a greenish to yellowish grey sandstone matrix identical with that of the Mekran fossils.

Akauktaung hills; Henzada, Burma. Coll. Murray Stuart. The matrix is similar to that of Theobald's specimens.

EXPLANATION OF PLATE 6.

Fig. 1.	Two lower valves. North of Talar gorge, Mekran province, Balúchistán.
Fig. 2 a, b.	Specimen with both valves united. Same locality.
Fig. 3.	Lower valve. Khayu Chaung, southern Pegu Yoma, Burma.
Fig. 4 a, b.	Specimen with both valves united. Same locality.

MR. T. R. BLYTH.

IT is with extreme regret that I have to record the death, on March 21st, of Mr. T. R. Blyth, Assistant Curator, Geological Museum and Laboray.

Originally a pupil of the Jesuit Fathers at St. Xavier's College, Mr. Blyth was appointed to the post of Museum Assistant, Geological Survey of India, in the year 1884. His conscientiousness and diligence speedily enabled him to profit to the fullest extent by the advantage of training under Mr. F. R. Mallet, then Curator, and for many years, both in the Museum and in the Laboratory, his services have been invaluable. In the year 1900, he was placed in charge of the Geological Survey exhibit at the Paris Exhibition and the high character of his work received recognition in the personal award to him of a special diploma and gold medal.

Mr. Blyth's long service of twenty-seven years was a steady record of whole-hearted but unobtrusive devotion to duty, and throughout the period he won the esteem and affection of every member of the Department. His loss will be long and keenly felt.

H. H. HAYDEN.

MISCELLANEOUS NOTES.

Note on Braunite Crystals from some New Localities.

On pages 55 to 62 of Vol. XXXVII of the Memoirs of the Geological Survey of India, an account has been given, with figures, of crystals of braunite from five localities, namely, Kajlidongri in Central India, and Kacharwahi, Kodegaon. Lohdongri, and Sitapar, in the Central Provinces.

Since the foregoing was written crystals of this mineral have been obtained from the following additional localities :—

6. Thirori, Balaghat district. }
7. Kachi Dhana, Chhindwara district } Central Provinces.
8. Satak, Nagpur district }
9. Gariajhor, Gangpar State, Bengal, and an additional supply of crystals from Sitapur.

A few notes on these new acquisitions are given below.

1. Thirori.

Two large well-crystallised specimens were presented by Mr. L. H. Bartlett. One of these specimens (K. 422) is a slab of massive crystalline braunite, 16 about cm. long by 12 cm. broad. One surface is occupied by braunite crystals, some of which would be 2 to 3 cm. long if doubly terminated. They are rough and dull, but the following faces can be recognised :—(001) or *c*, (111) or *p*, (421) or *x*, and (423) or *y*. The prevailing habit is shown in figure 1.

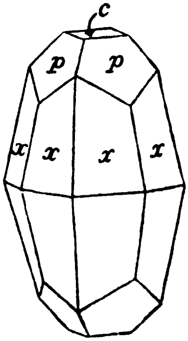


FIG. 1.—Braunite crystal from Thirori.

The smaller specimen (K. 423) shows braunite crystals in a decomposed felspathic matrix resting on fine-grained crystalline manganese-ore. The crystals measure up to 1 cm. in length and possess moderately bright faces. The forms present are *c*, *p*, *x*, *y*, and a bevelling face between *p* and *x*, which is probably *r* or (865). Most of the crystals are simple twins on *e* or (101).

2. Kachi Dhana.

Specimen K. 458 from this deposit consists of hard crystalline braunite-rock, with two patches of decomposed felspar (pinkish), one containing a little quartz. These contain small braunite crystals, sometimes isolated and sometimes growing from the ore at the edge of the patch. The largest crystal is less than 1 cm. long, and many are not more than one 1 mm. across. Most of the faces and edges are rounded and imperfectly developed, the only recognisable faces being *p* and *x*.

3. Satak.

Specimen K. 421 was found by Mr. E. L. Young at Satak II. It is 8 cm. long and shows cream-coloured to pinkish felspar attached to coarse-grained braunite-rock. The braunite crystals are scattered through the felspar, in one place lining a small cavity ; they range in length up to 1 cm, and are of the spindle-shaped habit typical of Kajlidongri and also common at Kacharwahi (see fig. 1, *l. c.*), showing a combination of *p* and *x*. There are also a few small hexagonal crystals of apatite in the specimen.

4. Gariajhor.

A single specimen (K. 454) from this locality was presented by Dr. A. W. G. Bleeck in 1908. He obtained it from the footwall side of the deposit near the top of Gariajhor Hill. Several braunite crystals up to 1-1·4 cm. in diameter are implanted on hard ore composed largely of the same mineral. On removing a crust of black oxide from the braunite crystals, shining faces are disclosed ; these faces are broken up by a network of dull black channels indicating the presence of a plexus of minute veinlets of a dull mineral, probably psilomelane. One crystal is coated with golden-bronze mica.

No new faces are shown. Of four readable crystals, three show combinations of *c*, *p*, and *x*, whilst the fourth shows one (100) or *a* face in addition, 0·8 cm. in diameter. The peculiarity of these crystals is the important development of the basal plane, rendering the crystals stumpy or even tabular, as illustrated in figure 2, which represents a small crystal measuring only 2 mm. from basal plane to basal plane.

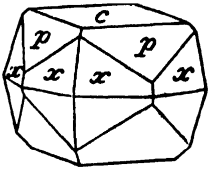


FIG. 2.—Braunite crystal from Gariajhor.

5. Sitapar.

From a crumbly rock (21·985) collected in 1907, and composed of braunite with a small amount of decomposed felspathic matrix, several imperfect crystals up to 1 cm. across have been extracted. The recognisable faces are *c*, *p*, *x*, and *y*, of which *p* is the common and dominant one, so that the crystals are roughly octahedral.

In many places the Sitapar ores contain patches and strings of a pale pink to white arsenate[1]; and where the ore itself is braunite the arsenate often contains isolated braunite crystals of black colour and splendent lustre. They are usually too rounded to be readable, but in one case (K 457), a combination of *p* with a small basal plane (*c*) can be recognised; and, in another crystal, *p* with well-developed *x* faces.

[L. L. FERMOR.]

Note on an Exudation on Coal from Mohpani, C. P.

Recently, Mr. F. L. G. Simpson, Manager of the Mohpani coal mines, sent some specimens of splint coal which were covered with a reddish waxy exudation, suggesting that it consisted of ferric sulphate, calcium sulphate, and alumina. A chemical examination showed that it was simply a basic ferric sulphate without calcium sulphate or alumina. The exudation absorbed moisture and deliquesced very quickly in the damp atmosphere of Calcutta. On drying, the substance becomes lighter in colour. There can be very little doubt that the formation of this exudation is due to the oxidation of iron pyrites in the coal.

[G. H. TIPPER.]

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[1] Since investigated by G. T. Prior and G. F. H. Smith and found to be a phosphate and arsenate of calcium and strontium, allied to apatite, and named by them fermorite.

Rectification of nomenclature: Noetlingaster,[1] nom. mut.

In the *Palæontologia Indica*, Ser. XVI, Vol. I, part 3, page 14, (1897), Dr. Noetling has described a very interesting Echinoid from the Maestrichtian beds of the Mari Hills in Balúchistán, for which he established a new genus which he designated as *Protechinus*. In a review of Dr. Noetling's monograph, Lambert noticed that the name *Protechinus* was pre-occupied for a Carboniferous genus established by Austin in 1860, and the name *Noetlingia* was proposed as a substitute to designate the Cretaceous fossil. Lambert's rectification was published in 1898 (*Rev. Crit. Pal.*, Vol. II, p. 126). A second species discovered in the Sahara, probably from the same geological horizon as the Balúchistán fossil was described by Gauthier in 1901 under the name of *Noetlingia Monteili* (*Bull. Soc. Geol. Fr.*, 4th ser., Vol. I, p. 189).

I find, however, that a genus *Noetlingia* had already been established in 1894 by Hall and Clark for a Brachiopod (*Natural History of New York Palæontology*, Vol. VII, Pl. II, pp. 228-229). So far as I am aware, the reduplication of this generic name has so far escaped notice, and if this is really the case, I propose altering the generic name of the Echinoid to NOETLINGASTER, since the right of priority for the name *Noetlingia* belongs to the authors who described the genus of Brachiopod.

[E. W. VREDENBURG.]

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[1] In the note originally communicated by me, I suggested the name *Noetlingiaster*. Mr. Lambert, to whom I had forwarded a copy of the note, kindly suggested that the form *Noetlingaster* would be more correct.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1911. [May

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1910. BY H. H. HAYDEN, B.A., F.G.S., *Director.*

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DISPOSITION LIST.

1. During the period under report the officers of the Department were employed as follows :—

Superintendents.

MR. C. S. MIDDLEMISS .	Deputed on the 11th June 1910 for field work in Kashmir. Returned to head-quarters on the 10th October 1910. Deputed to survey the Idar State and to be in charge of the Central India party for extension of the geological map over previously unsurveyed areas in Central India and the neighbouring States of Rajputana.
MR. H. H. HAYDEN .	Returned to head-quarters from Assam on the 19th April 1910 and placed in charge of the office on the 21st April 1910. Assumed duties of Officiating Director from the 24th October 1910.
MR. E. VREDENBURG .	Granted privilege leave for 3 months and 10 days from the 14th March to 23rd June 1910. At head-quarters as Palæontologist for the rest of the period under report.

Assistant Superintendents.

MR. P. N. DATTA . .	Returned from the field on the 9th April 1910. Granted privilege leave for six weeks with effect from the 20th October 1910. Returned from leave on the 1st December 1910 and deputed to Upper Burma.
DR. L. L. FERMOR . .	At head-quarters in charge of office up to the 20th April 1910. Granted privilege leave for 25 days combined with special leave for 5

	months and 5 days with effect from the 21st April 1910. Placed on deputation to attend the eleventh International Geological Congress at Stockholm. Returned from leave on the 15th October 1910 and placed in charge of the office on the 4th November 1910.
DR. G. E. PILGRIM . .	At head-quarters as Curator up to the 31st July 1910. Deputed to survey the freshwater Tertiary deposits of the Punjab and left for the field on the 30th September 1910.
MR. G. H. TIPPER . .	Returned to head-quarters on the 13th April 1910. Acted as Palæontologist from the 13th April to 31st July 1910. Appointed Curator on the 1st August 1910. Deputed on the 26th December 1910 to examine and report on the Samarskite deposits in the Nellore District, Madras.
MR. H. WALKER . .	Returned to head-quarters on the 11th September 1910. Granted privilege leave from the 31st October to 13th November 1910. Deputed on the 21st November 1910 to enquire into artesian water conditions in Gujarat. Returned from Gujarat on the 5th December 1910.
MR. E. H. PASCOE . .	Proceeded to Digboi on the 15th February. Returned to head-quarters on the 6th March 1910. Granted privilege leave for 23 days from the 1st to 23rd July 1910. Deputed on the 31st July to Yenangyaung. Returned from Burma on the 24th November 1910. Deputed on the 18th December 1910 to accompany the column despatched by the Government of Eastern Bengal and

	Assam to Makware in the administered territory to the east of the Naga Hills District.
MR. K. A. K. HALLOWES .	Returned from the field on the 8th May 1910. Granted privilege leave for one month with effect from the 20th October 1910. Returned from leave on the 19th November 1910. Deputed to Burma in connection with the survey of the Tertiary oil-bearing regions in Upper Burma and left for the field on the 27th November 1910.
MR. G. DE P. COTTER .	Returned to head-quarters on the 5th May 1910. Granted privilege leave for 2 months and 10 days combined with furlough on medical certificate for 3 months and 21 days with effect from the 20th October 1911.
MR. J. COGGIN BROWN .	Returned to head-quarters on the 24th May 1910. Granted privilege leave for 3 months combined with special leave for 3 months with effect from the 19th August 1910.
MR. J. J. A. PAGE .	Granted 6 months' extension of leave on medical certificate. Returned from leave on the 5th September 1910. Deputed on the 31st October 1910 to survey the Dalbhum Estate, Singhbhum.
MR. H. C. JONES .	In addition to the survey of the Gwalior State, employed from the 11th February to 31st March 1910 to report on dam-sites in the Jhelum and Mianwali Districts, Punjab. Returned to head-quarters on the 25th May 1910. Deputed from the 26th to 31st July 1910 to inspect the reservoir site of

	Nainpur, Central Provinces. Re-posted to Central India for continuation of the survey of Gwalior State and left for the field on the 28th October 1910.
MR. A. M. HERON .	Returned from the field on the 24th May 1910. Re-posted to the Central India and Rajputana party. Left for the field on the 11th November 1910.
MR. M. STUART . .	Returned from the field on the 31st May 1910. Granted privilege leave for 3 months with effect from the 18th November 1910.
MR. N. D. DARU . .	Returned to head-quarters on the 21st May 1910. Deputed to the College of Science, Poona, as lecturer on Geology from the 13th June to 31st December 1910.

Chemist.

DR. W. A. K. CHRISTIE .	Deputed from the 5th to 17th March 1910 to collect samples from the Lonar Lake. Granted privilege leave for 3 months and in continuation leave on medical certificate for 3 months with effect from the 8th July 1910. At head-quarters for the rest of the period under report.

Sub-Assistants.

S. SETHU RAMA RAU .	Returned to head-quarters on the 19th May 1910. Granted privilege leave for 1 month and 23 days with effect from the 19th September 1910. Returned from leave on the 11th November 1910. Posted to the Burma party and left for the field on the 18th November 1910.

M. VINAYAK RAO . .	Returned from the field on the 2nd June 1910. Deputed to collect mammalian remains in the Siwalik rocks of the Punjab under the direction of Dr. Pilgrim and left for the field on the 24th October 1910.

Assistant Curator.

MR. T. R. BLYTH . .	On duty at head-quarters throughout the period under report.

ADMINISTRATIVE CHANGES.

2. Sir T. H. Holland, Director, was permitted to retire with effect from the 1st December, 1910.

Mr. T. H. D. La Touche, Officiating Director, was permitted to retire with effect from the 30th October, 1910.

3. Mr. H. H. Hayden, Superintendent, was appointed to officiate as Director with effect from the 30th October, 1910, and was confirmed in that appointment from the 1st December, 1910, *vice* Sir T. H. Holland.

Mr. G. H. Tipper acted as Palæontologist from the 13th April to 31st July, 1910, and was appointed Curator with effect from the 1st August, 1910.

Mr. E. Vredenburg, Officiating Superintendent, was confirmed in that grade with effect from the 30th October, 1910, *vice* Mr. T. H. D. La Touche retired.

Dr. L. L. Fermor, Assistant Superintendent, was appointed to officiate as Superintendent with effect from the 30th October, 1910, and was confirmed in that grade from the 1st December, 1910, *vice* Mr. H. H. Hayden appointed Director.

4. Mr. E. Vredenburg was granted privilege leave for 3 months and 10 days, with effect from the 14th March, 1910.

Leave.

Dr. L. L. Fermor was granted privilege leave for 25 days combined with special leave for 5 months and 5 days with effect from the 21st April, 1910.

Mr. P. N. Datta was granted privilege leave for 6 weeks with effect from the 20th October, 1910.

Mr. H. Walker was granted privilege leave for 14 days with effect from the 31st October, 1910.

Mr. E. H. Pascoe was granted privilege leave for 23 days with effect from the 1st July, 1910.

Mr. K. A. K. Hallowes was granted privilege leave for one month with effect from the 20th October, 1910.

Mr. G. de P. Cotter was granted privilege leave for 2 months and 10 days combined with furlough on medical certificate for 3 months and 21 days with effect from the 20th October, 1910.

Mr. J. Coggin Brown was granted privilege leave for 3 months combined with special leave for 3 months with effect from the 19th August, 1910.

Mr. J. J. A. Page was granted furlough on medical certificate for 6 months in extension of privilege leave for 3 months granted from the 9th December, 1909.

Mr. M. Stuart was granted privilege leave for 3 months with effect from the 18th November, 1910.

Dr. W. A. K. Christie was granted privilege leave for 3 months and, in continuation, furlough on medical certificate for 3 months with effect from the 8th July, 1910.

RETIREMENTS.

5. During the past year, the Department has suffered unusually heavy loss in the retirement of its two senior members, Sir Thomas Holland and Mr. T. D. La Touche, who retired respectively on November 30th and October 29th, 1910.

Sir Thomas Holland joined the Department in 1890, and, on being appointed to the post of Curator of the Museum and Laboratory, at once gave evidence of that administrative genius which has been such a characteristic feature of his official career. Promoted to Deputy Superintendent in 1894 and Officiating Superintendent in 1895, he was finally selected to succeed the late Mr. C. L. Griesbach in the post of Director in February, 1903, a record unique in the annals of the Geological Survey. At the same time, the publications of the Department bear witness to his great scientific activity during this period, and we owe to him most of the advances that have been made in recent years in Indian petrography. His elucidation of the nature and origin of the Charnockite series, of the elaeolite-syenites and corundum-syenites of Sivamalai and of numerous other rock-types of the Madras Presidency, constitute little less than a revolution in the methods of geological investigation in the Peninsular areas. These and his other valuable researches, not only in the realms of Geology but also of Anthropology, led to his election to a Fellowship of the Royal Society in the year 1904.

In the internal administration of the Geological Survey he has been no less successful, and the re-organization of the Department in the year 1906, with consequent increase of staff, was due entirely to his efforts. Throughout his service, his chief aim has been to ensure that the extensive scientific researches carried out by his Department should not be divorced from their legitimate object, the ultimate development of the mineral resources of the country, but that, while still constituting important additions to purely scientific investigation, their value should be further enhanced by the due appreciation of their economic significance. Conversely, investigations undertaken primarily for purely economic purposes have equally been made to yield valuable scientific results. Examples of such investigations are to be seen in the memoirs published by the Geological Survey on Corundum, Mica, and Manganese. The result of this policy has been not only a largely augmented scientific output, but such an increase in the number of applications for assistance and advice made to the Department both by officials as well as by the general public, that it has been found necessary to make urgent representations to the Government of India for sanction to an increase of the clerical staff, which is at present unable to cope with the steady growth of correspondence. This, of course, is only the reflection of the general activity in mineral development which has been so marked in India during recent years and which has coincided in a remarkable manner with Sir Thomas Holland's tenure of the post of Director. Although it may not be justifiable to attribute such activity entirely to the general policy adopted by Government at his suggestion, the coincidence can certainly not be regarded as merely fortuitous.

The value of Sir Thomas Holland's services received recognition at the hands of the Government of India in the year 1908, when he was created a K.C.I.E. The fact that he has been President of the Asiatic Society, President of the Mining and Geological Institute of India, and Chairman of the Trustees of the Indian Museum, bears eloquent witness to the width of his sympathies, and it is safe to say that his early retirement is regretted not only by the members of his own Department, but by all those interested in scientific as well as industrial progress in India. Although no longer an active member of the Geological Survey, his interest in it has not diminished; and we hope to find in him the ever-ready friend and helper that we lost with the death of Dr. Blanford.

6. Mr. T. D. La Touche joined the Geological Survey towards the end of the year 1881 and during his long service of nearly thirty years has contributed largely to our knowledge of Indian geology, not only in its purely scientific aspects, but also in its more practical bearing on the mineral resources of the country. The ground covered by his many published papers is remarkable for its width and variety, ranging from detailed petrography, as embodied in his description of the igneous rocks of Western Rajputana, over the whole field of structural, physical and stratigraphical geology. His scientific researches have extended from the confines of Baluchistan on the west to the Burmo-Chinese frontier on the east, whilst his acquaintance with the coal-bearing rocks of the Himalayan areas and Assam is unique. During the latter part of his service he was engaged on a survey of the Northern Shan States, which resulted in many valuable discoveries bearing on the questions of the extension of Asian zoo-geographical provinces during the Palæozoic era and the relationship of the various Indian marine faunas of early geological ages to those of Europe and America. The administrative duties of the Director of the Geological Survey leave but little time for scientific research and during his tenure of that office from September, 1909, until his retirement, his spare time was occupied chiefly in preparing for the press the results of his work in Burma; he was also able, however, to edit the journals of Major James Rennell, the first Surveyor-General of India, and to superintend their publication in the Memoirs of the Asiatic Society.

Mr. La Touche's services to Indian science were acknowledged in his selection as one of the first Fellows of the Asiatic Society of Bengal, of which Society he was subsequently elected President, an office that he filled at the time of his retirement.

STUDENTS.

7. The practice, inaugurated three years ago of training students as prospectors on behalf of Native States, has been continued with a considerable measure of success. Four such students completed their training during the year under review: *viz.*, S. R. Ghatpande (Indore State), Byas Shankar Lall, B.A., (Marwar), Sheoprasad Gargava, B.A., (Gwalior), and Lala Joti Parshad, B.A., (Kashmir).

Each of these has now returned to his State, where his services should be of value to the Darbar.

8. The Bengal Government Research scholar, Babu Kiran Kumar Sen Gupta, completed his course of research work on March 31st, and obtained an appointment as Geologist to the Cochin State.

9. Sayad Abdul Karim, B.A., who is being trained on behalf of the Hyderabad Darbar, had completed three-quarters of his course at the end of the year. After spending the first few months undergoing training at head-quarters, he was permitted to accompany the Presidency College class to the Himalaya during the summer vacation and was attached to the Central India party for field-work during the season 1910-11.

UNIVERSITY LECTURES.

Presidency College, Calcutta.

College of Science, Poona.

10. Mr. E. Vredenburg continued to be lecturer on Geology at the Presidency College, Calcutta, throughout the year. The success which has attended the practice of allowing a member of the Geological Survey to carry on this work in addition to his other duties, has led the Government of India to sanction its extension to the College of Science, Poona, and Mr. N. D. Daru, Assistant Superintendent, was permitted to take up the post of Lecturer in Geology at the latter Institution for the term beginning in June and ending in September, 1910. At the request of the Bombay Government his services were lent for a further period of three months to enable him to complete the re-arrangement of the geological collections belonging to the College of Science.

Presidency College, Madras.

11. It was also decided by the Government of India that a member of the Geological Survey should be transferred for a period of three years to the Madras Educational Department to act as Professor of Geology at the Presidency College, Madras. Mr. Murray Stuart was selected for this appointment and his services will be transferred early in the year 1911.

PUBLICATIONS.

12. The publications issued during the year under review comprise two volumes of *Records*, one of *Memoirs*, and two fasciculi and one memoir of *Palæontologia Indica.*

LIBRARY.

13. The additions to the Library during the period 1st January to 31st December 1910 amounted to 3,539 volumes, of which 2,472 were acquired by presentation and 1,067 by purchase.

DRAWING OFFICE.

14. Mr. H. B. W. Garrick was absent on leave until August 3rd. Since his retrun he has spared no pains to ensure the excellence of the work of the Department under his charge and his zeal and energy are worthy of the highest commendation.

15. The recent increase in the gazetted staff in consequence of the re-organisation of the Geological Survey has led to a larger output of maps and an increased demand for illustrations for the publications of the Department. This has resulted in the work of the Drawing Office being carried on at high pressure throughout the year, and a limit has been reached beyond which it is impossible to go without further assistance. A scheme which has been under consideration for some years, for increase of the subordinate staff, is now being prepared for submission to Government.

16. The half-tone process work, which was successfully inaugurated two years ago, has been greatly hampered by the difficulty of obtaining the services of a suitable artist. The man originally employed gave entire satisfaction, but, owing to his death early in the year, it has been necessary to find a substitute. This has been extremely difficult for various reasons, one being the high rate of pay demanded by workers of this class. A temporary appointment, however, has recently been made and gives every promise of being satisfactory.

17. A new edition of the Geological map of India on a scale of 1 inch=32 miles has been completed and a limited number of copies have been reproduced in black and white by the Photo-Litho Department of the Survey of India. The geological colouring of these will be a matter of some considerable time, as the work is very complicated and will all be done by hand.

MUSEUM AND LABORATORY.

Staff.

18. Dr. G. E. Pilgrim was Curator of the Museum and Laboratory until the end of July when Mr. G. H. Tipper was appointed. Mr. T. R. Blyth was Assistant

Curator throughout the year; as usual his services were invaluable. Babu Bankim Behari Gupta has continued to work creditably.

Determinative and Chemical work.

19. The number of specimens referred to the Curator for examination and report was 533, an increase of 172 over that of the previous year. Assays and analyses were made of 67 of these, 28 more than in 1909.

Meteorites.

20. Three meteoric falls were recorded in India during the year. The localities and dates are as follows:—(1) Mirzapur, 7th January, (2) Bilaspur, Simla district, 15th September, (3) Khohar, Banda district, 19th September. Parts of all these falls have been acquired for the collection.

21. The work of re-arranging and re-labelling the rock and mineral collections has been continued throughout the year.

Collections of minerals and rocks have been received in exchange from the Muséum d'Histoire Naturelle, Paris, the Geological Survey of Canada and the Rhodesian Museum.

Museum.

22. The fossil vertebrate collections in the Siwalik Gallery were completely rearranged by Dr. G. E. Pilgrim. The entire Indian collection is now arranged in zoological order, both the specimens on show in the table cases, as well as the duplicates contained in the drawers. This new grouping has chiefly affected the Pleistocene fossils, which were formerly separated from the Miocene and Pliocene forms; it has given considerably more space for the large number of specimens acquired during the last four years. A good beginning has also been made in the re-labelling of the collection and printed labels are now being substituted for the hand-written ones.

23. The work of classifying the specimens in the Fossil gallery has been continued. The collections include a large series of European ammonoids which have hitherto remained classified under the broad designations *Goniatites*, *Ceratites* and *Ammonites*. These have been re-distributed by Mr. Vredenburg according to modern nomenclature, with short diagnoses of the various genera.

24. Mr. Vredenburg has also sorted out and identified a large collection of ammonoids from the Lower Trias of the Salt Range, constituting a portion of the material gathered by Dr. Noetling in 1899-1900.

The ammonoids include the following 25 species (every reservation being made as regards the generic attributions):

Celtites radiosus, Koken.
,, *fortis*, Koken.
,, *fallax*, Koken.
,, *armatus*, Waagen.
,, *acuteplicatus*, Waagen.
Xenodiscus perplicatus, Frech.
Proptychites obliqueplicatus, Waagen.
Gyronites frequens, Waagen.
Flemingites glaber, Waagen.
,, *trilobatus*, Waagen.
,, *Flemingianus*, Waagen.
Prionolobus rotundatus, Waagen.
,, *atavus*, Waagen.
,, *undatus*, Waagen.
Koninckites Davidsonianus, de Koninck.
,, *volutus*, Waagen.
Hedenstroemia Mojsisovicsi, Diener.
Meekoceras pulchrum, Waagen.
,, *fulguratum*, Waagen.
Pseudosageceras multilobatum, Noetling.
Ambites discus, Waagen.
Aspidites superbus var. *præcursor*, Frech.
"*Acrochordiceras*" *coronatum*, Waagen.
"*Ceratites*" *Murchisonianus*, Waagen.
Stephanites superbus, Waagen.

There are also some specifically indeterminable fragments of *Sibirites* and *Prionties*.

This number seems very small as compared with the 136 named forms described by Dr. Waagen in the *Palæontologia Indica*, Series XIII, Volume II, part 1 (1895), all the more so as 7 amongst them are unrepresented in Waagen's monograph, being species described and recognised by Frech, Koken and Noetling amongst the material collected by the two latter geologists in 1902-1903. The poor state of preservation of the material originally described by Waagen is largely responsible for this discrepancy. According to Mr. Vredenburg, many of the species established by Waagen represent different modes of preservation of one and the same form. This is particularly the case with the species and genera founded on the supposed absence of denticulations along the sutural lobes. In the case of the Salt Range specimens this appears to be invariably the result of weathering.

Other Museums.

25. A collection, chiefly of marine fossils of eocene age, was received from the Quetta Museum for determination. The specimens were examined by the Palæontologist and, after identification, were returned to Quetta.

INTERNATIONAL GEOLOGICAL CONGRESS.

26. Cut off as geologists in India necessarily are from constant intercourse with the general body of scientific investigators, it is especially desirable that the members of the Geological Survey should be given every opportunity of coming into personal contact with the geologists of other countries. The opportunities afforded by the meetings of the International Geological Congress are unique in this respect, and advantage was taken of the fact that Dr. L. L. Fermor was in Europe on furlough, to depute him to attend the 11th meeting held at Stockholm in August and subsequently to take part in various excursions. Dr. Fermor has submitted a report which will be published in a subsequent number of these *Records.*

SEISMOLOGY.

27. At the end of 1909 and beginning of 1910, Mr. A. M. Heron visited the scene of the Baluchistan earthquake of October 21st 1909; his paper on the subject has already been published in the preceding part of these *Records* (Vol. XLI, p. 22).

MINERALOGY AND PETROLOGY.

Indian arsenates.

28. In his monograph on the manganese-ore deposits of India[1] Dr. Fermor has given a preliminary account of two occurrences of arsenates in Indian manganese mines. The best material available was forwarded to the British Museum (Natural History) for further investigation, which was kindly undertaken by Dr. G. T. Prior and Dr. G. F. H. Smith. From the summary at present available of their papers read before the Mineralogical Society of London[2] it appears that the green mineral found at Kajlidongri in

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[1] *Mem. Geol. Surv. Ind.*, XXXVII, pp. 218, 219, (1909).

[2] *Nature*, Feb. 17, 1910, p. 477, and June 23, 1910, p. 513.

Tilasite.

Jhabua State, Central India, is a fluo-arsenate of magnesium and calcium with the chemical formula (MgF) $CaAsO_4$, a specific gravity of 3·768, a hardness of 3½, and monoclinic crystallisation. It is probably identical with tilasite, described in 1895 by H. Sjögren from the famous Swedish manganese mine of Långban, and named after a Swedish mining engineer, D. Tilas. The Swedish mineral differs from the Indian in having a grey colour with a violet tinge. From the Indian material, much of which was generously contributed by Mr. H. J. Winch, it has been found possible to work out the crystallographic characters of the mineral, for which purpose the Swedish material was too imperfect.

Fermorite.

The other mineral, that found at the Sitapar manganese mine in the Chhindwara district of the Central Provinces, where it is fairly abundant as a white to pale pink mineral associated with hollandite, braunite, sitaparite, and psilomelane, has proved to be an arsenate and phosphate of both calcium and strontium. It is to be regarded as the arsenic analogue of apatite, with which the Sitapar mineral seems to agree in crystallographic characters, as far as can be judged from the material available, for no really well-crystallised specimens have yet been found. The name fermorite has been proposed for this mineral.

The occurrence of these two arsenate minerals in the Indian manganese deposits is of considerable interest, for perhaps one of the most striking facts known with regard to the distribution of minerals is the presence of some 20 species of arsenates and antimonates—most of them not found elsewhere—in the Swedish iron-manganese mines of Långban, Pajsberg (Harstig mine), Nordmark (Moss mine), and Jakobsberg, in Wermland, and of Sjö in the province of Örebro. Nearly all of these minerals contain manganese as an essential constituent, but a few of them, including tilasite, are free from this element. In view of the fact that both the Swedish and the Indian deposits in which the arsenates occur are of Archæan age, it is not unlikely that careful scrutiny of the Indian deposits during their exploitation may lead to the discovery in India of other arsenates, and perhaps also of antimonates.

29. Crystals of braunite, of which an account is embodied in a note in the preceding part of this volume of the *Records* (*supra*, p. 43), have recently been obtained from some additional localities in the Central Provinces (Thirori, Kachi Dhana, and Satak), and from Gariajhor in Gangpur State, Bengal, the extension into which of the gondite

series of the Central Provinces has already been noticed in the General Report for the year 1908.

Samarskite, cyrtolite, allanite.

30. Mr. Tipper made an examination of the minerals occurring in the Sankara mica mine, Nellore district, Madras Presidency. The occurrence of samarskite in this mine has already been noted. The other minerals identified from the mica-bearing pegmatite are cyrtolite and allanite. The cyrtolite occurs in sheaf-like aggregates of crystals usually terminated by prism faces but sometimes with strongly curved pyramid faces as in the original cyrtolite. This mineral would seem to be a hydrated variety of zircon containing a small percentage of uranium. A determination of the amount of uranium gave 1·56 per cent. $U_3 O_8$. Further traces of the rare earths are present. Microscopic examination shows that the mineral has undergone very considerable alteration.

The allanite is in long crystals, surrounded by brownish altered epidote, and occurs in a rock composed of garnet, mica and little felspar. Bands of this rock are common in this particular locality and are part of the pegmatite mass.

Wolframite.

31. A large series of specimens of wolfram from Burma, collected by Mr. Page, was examined in order to ascertain if any of them could be classed as hübnerite. All, however, proved to be typical wolframite.

Rocks of Central India and Rajputana.

32. Messrs. Heron and Jones were engaged, during the recess, in working out the microscopic characters of the rocks collected by them in Alwar and Gwalior respectively, and Mr. Heron will shortly publish a memoir embodying the results of his work.

PALÆONTOLOGY.

Indian Ostreidæ.

33. Mr. Vredenburg, who acted as Palæontologist throughout most of the year, has been engaged on a study of the Indian fossil *Ostreidæ*, based on the collections preserved in the Geological Museum; these include specimens from India and from Central Asia. The first instalment of the work will shortly be published in the *Palæontologia Indica*, and deals with *Ostrea s. s.* including the species provided with a ribbed lower valve and an opercular valve without radial ribs. The species dealt with have been classified in the following groups:—

Group of *Ostrea flabellula.*

O. multicostata, Deshayes.
O. angulata, J. de C. Sowerby.
O. latimarginata, Vredenburg.
O. cubitus, Deshayes.

Group of *Ostrea elegans.*

O. Cossmanni, Dolfus.
O. Fraasi, Mayer-Eymar.
O. gajensis, nov. sp.
O. gajensis, var. *Feddeni*.
O. orissensis, nov. sp.

Group of *Ostrea digitalina.*

O. digitalina, Eichwald, var. *Rholfsii*, Fuchs.

Group of *Ostrea fimbriata.*

O. turkestanensis, Romanowski.
O. Esterhazyi, von Pavay.

All the species occur in Tertiary strata ranging from Lower Ranikot (landenian) to Upper Hinglaj (middle miocene). *Ostrea Cossmanni* (*O. plicata* auct.) has been found in the Laki stage; *O. multicostata* characterises both the Laki and Khirthar. *Ostrea cubitus* and *O. Fraasi* occur in the Nari; *O. turkestanensis* has been found in the upper Nari; *O. angulata* occurs in the Nari and Gaj and is succeeded in the uppermost Gaj by its mutation *O. latimarginata*. *O. gajensis* also characterises the upper Gaj beds; *O. digitalina* occurs in the Lower Hinglaj of Baluchistan and in beds of corresponding age in Burma; *O. orissensis* is found in Upper Tertiary beds in the coastal district of Orissa.

Ostrea digitalina is identical with the Burmese form described by Noetling as *Ostrea promensis*.

The forms classified by Mr. Vredenburg within the group of *Ostrea elegans* are remarkable on account of their gradual evolution, which can be followed through successive geological periods. The eocene and miocene forms *O. Cossmanni* and *O. gajensis* appear perfectly distinct from one another, but the oligocene form *O. Fraasi* constitutes an intermediate mutation closely connected with both species. The group has survived to the present day in the Indian Ocean where it is represented by *Ostrea nigromarginata* Sow. in which the ribs have become almost obsolete, but which agrees with the fossil forms in all other characters.

Marine cretaceous near Tanjore.

34. The discovery of marine Cretaceous beds in a railway cutting was reported to Messrs. King and Foote subsequently to their examination of the country south of the Cauvery river, but they were unable to confirm the correctness of the report. The rocks have been rediscovered by Mr. Allan Campbell and include friable argillaceous sandstones underlying the Cuddalore series. They include fossil bryozoa, and casts of bivalves some of which are probably referable to *Inoceramus Cripsi.* These rocks probably represent a southern continuation of the Arialur rocks that outcrop to the north of the Cauvery delta.

Siwalik Vertebrates.

35. A memoir on the fossil *Giraffidæ* of India by Dr. G. E. Pilgrim has been completed. The chief feature of this memoir is the prominence which has been given to the exact horizon at which each species occurs. Two new and primitive genera have been founded, *Progiraffa* and *Girraffokeryx* from the Nari and Lower Siwaliks. The discovery of a skull of the species *Hydaspitherium grande* Lydekker, proves its generic identity with that of *Helladotherium* of the Pikermi beds. The new generic name of *Indratherium* has been proposed for the large skull obtained by Falconer from the Markanda valley below Nahan. The Upper Siwalik and Middle Siwalik *Giraffæ* have been specifically separated and two new species of *Hydaspitherium* have been established.

The collection of fossil vertebrates made during the two last years from the Middle and Upper Siwaliks of the Salt Range, has been examined and several new genera and species of mammals have been described in a preliminary notice (*Records*, XL, 63).

A memoir has been written containing full descriptions of the vertebrate fauna of the Upper Nari series of the Bugti Hills and the Punjab. This contains several additions and amendments to the preliminary list which was published in 1909 (*Records*, XXXVII, 139); these occur especially in the *Rhinocerotidae.*

36. During the year under review, a large amount of palæontolo-

Palæozoic fossils of the Himalaya and Afghanistan.

gical work was done on behalf of the Geological Survey by Mr. F. R. Cowper Reed in England and Dr. C. Diener in Austria. Mr. Cowper Reed has described the collections of Ordovician and Silurian fossils made from time to time by members of the Department in the Central Himalaya and, in a paper published in these *Records* (Vol. XL, p. 1, 'Pre-Carboniferous Life-Provinces'), has discussed their affinities to faunas of other parts of the world. He has also examined and described a suite of Devonian fossils which include a collection sent to the Geological Survey some years ago by Lieutenant Grant from the Baroghil Pass in Chitral, my own collection from the Hajigak limestone of Afghanistan, a small number of specimens collected by the late Mr. C. L. Griesbach in Khorasan, others obtained by Messrs. Griesbach and Smith in Byans and a small collection made by the late Dr. von Krafft and by me from the base of the Lipak series in Kanaur and Upper Spiti. It is an interesting fact that the facies of all these fossils is essentially European. Mr. Reed's paper is published in this number of the *Records*.

37. One of the many valuable results of Mr. Middlemiss' work during the last three years in Kashmir, has been the discovery of Silurian fossils, hitherto unrecorded from any part of that State. The specimens, which were referred to by Mr. Middlemiss in his paper on the Silurian-Trias Sequence in Kashmir (*Records*, XL, p. 213), were sent to Mr. Cowper Reed who has very kindly examined them and has furnished the following results, which are, however, only provisional. The fossils come from four localities:

(*a*) Gudramer (lat. 33°48′ : long. 75°27′) :

Calymene Blumenbachii Brong. *var.*
Illænus cf. *Thomsoni* Salt.
Acidaspis aff. *deflexa* Lake.
Phacops sp. ?
Primitia sp.
Beyrichia sp.
Turrilepas ? sp.
Orthis elegantula Dalm.
,, ,, *var.* (cf. *canalis* McCoy).
,, *basalis* Dalm. *var.*
,, *sowerbyana* Dav.
,, *crispa* McCoy.

Orthis calligramma Dalm. *var.*
Scenidium cf. *Lewisi* Dav.
Leptæna rhomboidalis Wilck.
Triplecia insularis Eichw.
Plectambonites aff. *papillosa* Reed.
Strophonella cf. *euglypha* His.
Strophomena cf. *antiquata* Sow.
,, sp.
Trematospira Salteri Dav. ?
Rhynchospira Bouchardi Dav. ?
Zygospira aff. *pentlandica* Haswell. ?
Wilsonia cf. *Wilsoni* Sow.
Rhynchonella (*Camarotœchia*) cf. *nucula* Sow.
,, ,, cf. *borealis* Schl.
Atrypa marginalis Dalm.
Merista or *Meristella* sp.
Nucleospira cf. *pisum* Sow.
Orthoceras cf. *tenuiannulatum* McCoy.
Cyrtoceras sp.
Lindstrœmia cf. *bina* Lonsd.
,, ? sp.

Probable age : Upper Llandovery or Wenlock. *Triplecia insularis* has not hitherto been found above the Upper Llandovery, but there is an absence of many typical Llandovery forms.

(*b*) Gugaldar (33°51′ : 75°25′), Harpatnar valley :

Calymene Blumenbachii Brong. *var.*
Encrinurus cf. *punctatus* Brunn.
Acidaspis aff. *coronata* Salt.
Orthis elegantula Dalm.
,, ,, *var.* (cf. *canalis* McCoy.)
,, *basalis* Dalm. *var.*
,, cf. *canaliculata* Lindstr.
,, aff. *edgelliana* Salt. ms.
,, cf. *crassa* Lindstr.
Plectambonites transversalis Dalm.
Scenidium cf. *Lewisi* Dav.
Merista or *Meristella* sp.
Nucleospira cf. *pisum* Sow.
Alveolites repens Fougt ?
,, ? sp.

Probable age : Wenlock, although the variety of species of Orthis and the absence of a more varied assemblage of fossils are unusual except in the Silurian of Ireland.

(*c*) Below Margan Pass, S. W. side (33°44′ : 75°32′) :

Conchidium cf. *Knighti* Sow. ?
Orthis sp.

Probable age : Aymestry Limestone, on the strength of the doubtful and poorly preserved example of *Conchidium.*

(*d*) Lutherwan (33°46′ : 75°35′) :

Calymene Blumenbachii Brong. *var.*
Acidaspis aff. *coronata* Salt.
Encrinurus sp.
Illænus ? sp.
Orthis elegantula Dalm.
,, *basalis* Dalm. *var.*
,, *rustica* Sow.
Scenidium aff. *Lewisi* Dav
Plectambonites transversalis Dalm.
Leptæna rhomboidalis Wilck. ?
Alveolites repens Fougt. ?
Coenites ? sp.

Probable age : Wenlock. The same remarks apply to this assemblage as to that from locality (*b*).

Anthracolithic fossils of the Shan States.

38. During the course of their surveys of the Northern and Southern Shan States respectively, Messrs. La Touche and Middlemiss obtained a considerable number of fossils of Upper Palæozoic age. These were sent to Dr. Diener for examination; his description of them is now in the press and will shortly be published in the *Palæontologia Indica.*

The fossils, which are derived from Kehsi Mansam and Namun in the Northern Shan States and from between Hopong and Möngpawn in the Southern, are regarded by Dr. Diener as equivalent in age to those of the Upper and Middle Productus Limestone of the Salt Range and the exotic block of Chitichun No. 1 in Tibet. Out of 47 species considered to be specifically determinable, 30 are either identical with or very closely allied to Salt Range forms. In each of the three localities the brachiopods form the most important section of the fauna, but at Namun the prevalence of *Bryozoa* also is very marked. The only trilobite, *Phillipsia sp. ind. aff.*

Middlemissii Diener, was collected by Mr. Middlemiss in the Hopong area, whilst *Fusulina elongata* Shumard is abundant at Kehsi Mansam. The latter fossil is of interest since it also occurs in considerable quantity in the Fusulina limestone of Bamian in Afghanistan.

Himalayan Trias

39. Dr. Diener has also completed a memoir on the distribution and development of the Trias of the Himalaya. This work originated from a paper which was being prepared at the time of his death by the late Dr. von Krafft, whose wide experience of both Alpine and Himalayan stratigraphical geology rendered him peculiarly fitted for the task. His notes on the subject were eventually forwarded to Dr. Diener, who has incorporated them in his paper, which will shortly be issued as *Memoirs, Geol. Surv. India,* Vol. XXXVI, pt. 3.

Fauna of the Spiti Shales.

40. The work of Professor Uhlig, on the ammonites of the Spiti Shales, which has extended over so many years, has now been finally completed and the last part ("Geological Results") has recently been received from the author. This will be translated by Mr. E. Vredenburg, who has devoted much time and care to the revision and editing of the later fasciculi.

The fauna of the Spiti Shales, so far as it is known at present, includes 218 species of ammonites, 4 of belemnites, 35 of lamellibranchs and two of gastropods. The lamellibranchs and gastropods have been described by Dr. Holdhaus, whose work has been translated by Mr. Vredenburg. From a study of the fauna, Dr. Uhlig has come to the conclusion that the various zones of the Spiti Shales extend from the Oxfordian to the Valanginian, both inclusive. The lower beds contain only a scanty fauna, the commonest fossil being *Belemnites Gerardi*. The bulk of the fauna is contained in the middle and upper subdivisions. The middle Spiti Shales or Chidamu beds appear to contain the equivalents of the Kimmeridge and Lower Tithonian, while the Infravalanginian (Berriasian) and Valanginian proper are undoubtedly represented in the Upper Spiti Shales or Lochambel beds which contain also Upper Tithonian fossil types.

The exact zonal distribution of the Spiti Shales fauna has not been fully worked out in the field; the detail of the subdivisions is difficult to follow owing to the lithological uniformity of the formation. Nevertheless, the abundance of fossils in the upper horizons may ultimately enable this research to be successfully carried out.

From the character of the fauna and of the deposit, Dr. Uhlig concludes that the Spiti Shales were deposited in rather deep water at a distance from the coast. Rocks of similar character and with the same fossils have been described from the Sula Islands in the Dutch Indies. The Himalayan facies of the Upper Jurassic and lowermost Cretaceous shows very little similarity to that of the Russo-boreal region, being much more nearly related to the fauna of same age in the Mediterranean region.

Fauna of the Giumal Sandstone.

41. The fossils collected at various times, by Dr. Stoliczka, Mr. Griesbach, Dr. von Krafft and myself, from the Giumal Sandstone of the Himalaya, have been worked out by Dr. Albrecht Spitz, whose descriptions of them will shortly be published in these *Records*. Dr. Spitz regards the Giumal Sandstone as ranging in age from middle neocomian to the base of the Upper Cretaceous.

ECONOMIC ENQUIRIES.

Coal.

Assam.

42. During the field-season of 1909-10, I visited the Saffrai and Taukak valleys with a view to examining the coal outcrops that had not already been reported on by Mr. R. R. Simpson.[1] As the results of my investigations have already been published in these *Records* (Vol. XL, p. 283), they need not be further referred to here.

Bengal

43. Throughout the greater part of the year, Mr. H. Walker was still engaged in a survey of the Raniganj Coalfield in connection with the large-scale map now under preparation by the Mining and Geological Institute of India, but before completion of the office work in connection with this, he was unfortunately compelled to take sick leave, and the map still remains unfinished. It is hoped that Mr. Walker will be able to complete his share of the work soon after his return from leave.

Burma.

44. Mr. M. Stuart examined certain localities in Henzada district where coal-seams were reported to occur. The chief outcrops are at Posugyi, Kywezin,

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[1] *Rec., Geol. Surv. India*, XXXIV, 199.

Hlemauk and Kyibin. Of these Kywezin seems to be the only area worth further attention; the coal there is very friable and greatly crushed, whilst the seam, which is about 10 feet thick, is much contorted. The composition of the coal, however, is good.

Punjab. Dandot boring.

45. The experimental boring at Dandot referred to in the last General Report (*Records*, Vol. XL, p. 95) was completed by Messrs. Kilburn & Co. in October, and coal was found at a depth of 309 feet from the surface. The seam, however, was only 1 foot 10 inches thick. Much difficulty was experienced in sinking the boring, owing chiefly to the cavernous nature of the nummulitic limestone and to the extreme softness of the intervening shales; so great was this difficulty that one hole had to be abandoned at a depth of 256 feet. I have to express my indebtedness to the Manager, North-Western Railway, for help in various ways, and especially to Mr. D. Thomson, Manager, Dandot Colliery, whose advice and assistance were as invaluable as they were ungrudgingly given.

It is now proposed to put down further borings in the neighbourhood of Tothral and Dalelpur in order to test the coal-measures below the nummulitic limestone towards the centre of the Dilwal plateau.

Engineering Questions.

46. At the request of the respective Local Governments, Mr. H. C. Jones was deputed to examine and report on proposed sites for dams at Ghori Gali, Pind Swika and Rhotas in the Jhelam district, Namal in the Mianwali district, Punjab, and near Nainpur in Mandla District, Central Provinces. His reports were forwarded to the local authorities concerned.

Galena.

Gwalior State: Mr. Jones.

47. In the course of his survey of the Gwalior State, Mr. H. C. Jones examined a deposit of galena occurring at Aindhar (lat. 25°32′ : long 78°8′). The galena occurs in small veinlets, patches and streaks, together with quartz and barytes, in a 5 ft. band in the gneiss, which apparently runs parallel to a quartz vein. Four pits had already been sunk somewhat

irregularly at the N. E. end of the band and a considerable amount of the ore proved. Mr. Jones suggested fresh localities for further trial pits and for a tunnel in the area S. W. of the pits already opened with the object of proving the band over a longer line of outcrop. He also made some suggestions as to leasing and smelting.

Iron-ore.

Chanda, Central Provinces.

48. Near the small village of Poser (19°56′ : 80°12′), the Archæan gneisses contain a band of hematite, which has been traced by Mr. P. N. Datta for a distance of 275 yards with an average thickness of about 20 feet and high dip to S. by E. The ore is almost theoretically pure hematite, and contains 69·8 per cent Fe. Mr. Datta was unfortunately unable to determine the extent of the ore-body.

Iron-ore was also observed in the quartz hills to the south-east of Chamoursi (19°56′· 99°57′) and in the range running from near Wingnur (19°46′ : 80°15′) to Emagarh (19°42′ : 80°33′), but the amount available is unknown.

Kirana Hills: Mr. Heron.

49. During a visit to the Kirana Hills, Mr. Heron took the opportunity of examining the iron and manganese-ores said to occur there in some quantity. Mr. Heron, however, found only traces of manganese, whilst the iron-ore proved to be of very poor quantity. Smelting, which was carried on on a small scale in the past, seems now to have been discontinued.

Monazite.

50. In consequence of the discovery of monazite sand in Travancore, Mr. G. H. Tipper was deputed to examine the coastal regions of that State on behalf of the Durbar. He found that certain beaches, chiefly along the west coast, were very rich in monazite, and consisted, in fact, of natural concentrates produced by the mechanical sorting action of the waves. Between Quilon and a point a few miles to the north-east of Cape Comorin, Mr. Tipper examined some seven deposits, in one of which he estimated that there must be at least 18,000 tons of pure monazite.

The mineral has also been found *in situ* in pegmatite near Thadikarenkonam, 14 miles north-west of Nagarcoil, and in the form of felspar-monazite rock, associated with graphite, in the leptynites and charnockites of Travancore.

Petroleum.

Assam.

51. Mr. E. H. Pascoe paid a flying visit to Digboi early in the year, with a view to drawing up a programme for a subsequent survey of the oil-bearing regions of Assam. For the rest of the year he was engaged on a memoir on the Burma oil-fields; this is now in the press and will shortly be ready for issue.

Burma.

52. During the field-season 1909-10, the following officers composed the Burma Oil-fields party: Messrs. G. de P. Cotter, K. A. K. Hallowes, M. Stuart and Sub-Assistant Sethu Rama Rau.

In addition to the examination of Kyundaw Island in Magwe and an area round Nyaungbintha village in Thayetmyo, Mr. Cotter carried out surveys of the areas comprised in the following sheets (1″=1 mile) :—

(*a*) Sheet 112 complete, with a small portion of the Minbu district in the south-western part of sheet 158 and a part of sheet 113 on the Pegu-Eocene boundary;

(*b*) part of sheet 110, to the east of the Irrawadi;

(*c*) sheet 84-K-16 complete, with the exception of the western boundary of the Yenangyat anticline, which was mapped by Sub-Assistant Sethu Rama Rau.

The first of these areas lies in the Minbu District, and its survey has thrown a considerable amount of light on the relations between the Pegu and Eocene series of this part of Burma. A paper on the subject will shortly appear in these *Records*. A section in the Kyetsu chaung shows that the Pegu beds form a sharply folded anticline, the dips on either side of which are approximately the same. The Pegu outcrops widen towards the south. Gas-pools occur to the south of the Kyetsu chaung, and four holes with bubbling mud were noticed in the same locality. There was, however, no sign of oil.

The second area (part of sheet 110 to the east of the Irrawadi) is covered by Plateau Gravel, Red Earth and Irrawadi beds.

Sheet 84-K-16 comprises the Pagan hills, which consist of sand stone and shale bent into a faulted anticline similar to that of Yenangyat. These, together with the Gwegyo hills and the Payagyigon-Ngashandaung anticline may be regarded as different wave-fronts of a single anticlinal fold. Fragments of the crest are seen on the north and on the south of the Naletaw Chaung. The crest-line is not continuous, but is broken by dislocation and faulting, and the rocks are often contorted. The curve of the anticline is very similar to that of Yenangyat, except that the beds on the west always dip more steeply than those on the west of the crest in the latter field. To the south the westerly-dipping Pegu beds are faulted against Irrawadi sandstone.

53. Mr. K. A. K. Hallowes was engaged in mapping the country shown on sheets 154 and 201 of the Burma Survey (1″=1 mile). The rocks comprised in this area include Red alluvium, members of the Irrawadi and Pegu series and a volcanic series of late Tertiary and post-Tertiary age. Tuffs, indicating the presence of an older volcanic group, were found interbedded with the Pegu sandstones of the Kyaukaingma anticline. The junction between the Irrawadi and Pegu series is said to be an unconformable one.

No oil-shows were found in this area, which is not regarded as of economic importance.

54. During the course of a survey of the Henzada district Mr. M. Stuart, examined various areas where oil was supposed to occur. He found nothing, however, which offered prospects of the discovery of an oil-field in this district.

55. Sub-Assistant Sethu Rama Rau mapped the area included in sheets (Burma Survey, 1″=1 mile) 155 and 84^{K}_{12} together with parts of 154, 112, 84^{K}_{13}, 84^{K}_{16}, and 84^{L}_{6}. Sheet 155 comprises three distinct anticlines, the Wetmasut, Yedwet-Wetchok and the Gwegon-Pongon. The first of these, which lies midway between Yenangyaung and Ondwe, appears to be a narrow fold with steep dips; the crest is formed by beds of doubtful age, which are perhaps uppermost Pegu. Although certain considerations tend to discount the value of this anticline as a source of oil, the general conditions point to it as being worth testing.

The Yedwet-Wetchok anticline has already been described by Mr. E. H. Pascoe (*Records*, Vol. XXXVI, p. 286).

56. The Gwegon-Pongon anticline is merely the continuation of the Kabat fold, and its prospects as an oil-field are similar to those of Kabat.

56. After completing sheet 155, Sub-Assistant Sethu Rama Rau undertook the mapping of the boundary between the Irrawadi and Pegu systems along the western edge of the Yenangyat oil-field. In conformity with Grimes' original classification (*Memoirs, Geol. Surv. India*, XXVIII, 43), the "Red Bed" was adopted as the basal bed of the Irrawadi system and the white sand as the uppermost division of the Pegu. The Red Bed has yielded various fossils, including vertebrate remains, whilst higher up in the series, near Tabingyaung, a calcareous zone, containing numerous Upper Siwalik forms, was traced for a considerable distance.

Opportunity was taken to measure the whole thickness of the Irrawadi system, which was found to be approximately 8,500 feet, as against Dr. Noetling's estimate of 20,000 feet. The fossiliferous calcareous band occurs at 8,000 feet above the Red Bed.

57. During the latter part of the field-season of 1909-10, Sub-Assistant Sethu Rama Rau examined and collected fossils from the neighbourhood of Payaywa and the Man Chaung near Ngape in Minbu district. At the village of Pinnebin, there is a coal-seam from 15 to 20 feet thick, overlain by a petroliferous sandstone. The coal is of poor quality, and often passes into carbonaceous shale; it does not appear to be of any economic value.

Oilfields Officer.

58. It having been decided that an officer of the Geological Survey should, at any rate for the present, reside continuously at Yenangyaung, Mr. E. H. Pascoe proceeded there at the beginning of August in order to advise the local authorities regarding questions that might arise in connection with the deepening of wells, casing off of water-sands, etc. Towards the end of November he was relieved by Mr. K. A. K. Hallowes.

Consequent on the recommendations of the Burma Oil-fields Committee, which sat in 1908 under the presidency of Sir Thomas Holland (*vide* General Report for 1908 in *Records*, Vol. XXXVIII, 48), the Upper Burma Oilfields Regulations, 1910, was enacted on the 28th October last. In conformity with the provisions of this Regulation, a Warden was immediately appointed for the Yenangyaung field, and steps are now being taken by the Local Government to constitute also an Advisory Board, of which it is proposed that an officer of the Geological Survey should be one of the members. It may, therefore, be found expedient for such officer to remain permanently at Yenangyaung; the matter is now under consideration, and arrangements have been made for him to reside there continuously for at least a year as an experimental measure.

Salt.

Salt Range and Sambhar: Dr. W. A. K. Christie.

59. A preliminary enquiry was made by Dr. W. A. K. Christie into the occurrence of salts of potassium in the rock-salt beds of the Punjab Salt Range. Two seams struck in the Mayo mine at Khewra and one in the small mine at Nurpur are promising enough to justify more extended prospecting operations, which it is proposed to carry out during the next field-season.

The Sambhar Salt Lake investigation was proceeded with on the system, adopted in the year 1907, by which 30 samples of lake and subterranean brine from different parts of the Lake are collected each year. Analysis of these has so far shown no definite depreciation in the composition of the brine as a result of salt manufacture.

Samarskite.

Nellore: Mr. G. H. Tipper.

60. The discovery of samarskite in India has already been recorded in a previous volume (*Records*, XXXVIII, 342), but until recently no opportunity had arisen of making a detailed investigation into its mode of occurrence. Owing to a request from the Madras Government for information on the subject, Mr. G. H. Tipper was deputed to Nellore for this purpose on December 26th; his enquiries should be completed early in 1911.

Tin.

Burma: Mr. J. J. A. Page.

61. Before leaving Burma for work in Singhbhum, Mr. J. J. A. Page paid a flying visit to Mawchi in Bawlake State, Karenni, in order to examine the tin mines of Kehdaung. The route chosen lay up the Salween from Tavoy, and, owing to lateness of the season and difficulties of transport, the journey was a most arduous one. Mr. Page found the rocks along the route to consist of various sedimentary types, including limestones, sandstones, slates and conglomerates, referable partly to the Mergui and partly to the Maulmain series. Granite and crystalline rocks are also prominent, and are pierced by quartz-

veins containing wolfram and cassiterite. The latter mineral also occurs in the granites. At Keh daung (=tin hill) the quartz-veins appear to be the only important mineral occurrence.

Trona.

Lonar Lake:
Mr. T. D. La Touche and Dr. W. A. K. Christie.

62. An investigation was made by Messrs. La Touche and Christie into the origin and the resources of the Lonar Lake in the Buldana District of Berar. This curious crateriform hollow measures about a mile and a quarter from crest to crest of its slightly raised rim, and on its muddy bottom, some 250 feet below the level of surrounding Deccan Trap country, is a shallow sheet of brine, from which urao (trona), a hydrated compound of carbonate and bicarbonate of soda, had been profitably recovered for many years. Stress of outside competition has, however, rendered the impure products obtained from the lake by simple evaporation almost unsaleable, and the enquiry was undertaken with a view to determining what the economic possibilities of the deposit really were.

The resources of the basin in so far as they could be ascertained without borings, have been determined and in a report now in the press suggestions have been made for their more efficient realisation. The vexed question of the geological structure of the neighbourhood, important on account of this being the only instance of late volcanic activity—if it really were such—in the Peninsula, has been fully discussed by Mr. La Touche, who, rejecting the theory of volcanic explosion suggested by Dr. W. T. Blanford and supported by Mr. R. D. Oldham, considers it to be due to a sudden inrush of vapour or molten rock from below through fissures that did not penetrate to the surface, the central part of the "blister" thereby formed afterwards collapsing into the hollow beneath, when a lateral fissure had allowed of the escape of the imprisoned gas or lava. The origin of the salts in the lake basin has also been discussed, the analytical data affording corroboration of Blanford's theory that the deposit is due simply to evaporation of the stream water in the absence of an exit.

Water.

63. In addition to the usual large number of references, both from officers serving under the various Local Governments as well as

from private individuals, on the subject of the prospects of artesian and other borings, special investigations were made into the conditions prevailing in various parts of Gujarat and Broach in the Bombay Presidency, and also at Ongole in Madras.

Gujarat.

In Gujarat, the scarcity of potable water has led to an attempt being made to obtain a sufficient supply either from artesian sources or from deep borings in the alluvium. It was originally suggested by the Geological Survey that trial borings should be put down in the neighbourhood of Wadhwan, but, owing to various considerations, sites were eventually chosen, by the local authorities, at Dholka and Sanand. A Calyx drill belonging to the Geological Survey was lent for the purpose, and borings were sunk into the alluvium; water was found at depths of 304 feet and 200 feet respectively at Sanand and Dholka. The borings were not carried through the alluvium, and the water was consequently not under artesian conditions. Although the water obtained at Sanand was finally found not to be potable the experiments, conducted by the Local Government are regarded as decidedly promising since they indicate the presence of water in considerable quantities at no great depth below the surface.

Broach: Mr. H. Walker.

64. Mr. H. Walker, who was deputed to examine various sites in Gujarat, came to the conclusion that there is a greater probability of obtaining water from deep borings in the alluvium than from artesian sources in the Tertiary and Mesozoic rocks underlying it. At Broach, on the other hand, he is of opinion that an artesian supply may be obtained from the Tertiary sandstones and grits which crop out to the south-east and, dipping towards the north-west at angles varying from between 30° and 40° to between 5° and 10°, pass under the Nerbudda alluvium on which the town stands. Mr. Walker recommends that, if necessary, a boring should be carried to a depth of 2,000 feet. He does not expect that the artesian conditions will be sufficiently perfect to cause the water to flow at the surface, and a certain amount of pumping would probably be necessary.

Ongole: Mr. G. H. Tipper.

65. With a view to devising a scheme for increasing the water-supply of the town of Ongole, Mr. G. H. Tipper was deputed to make a detailed examination of the neighbourhood. He found that the local conditions were unpromising. The town lies, at a considerable

distance from rivers of any size, on the northern slopes of a small range of hills composed of hornblende-schist, the foliation planes of which dip towards the south. The range is surrounded by a narrow strip of lateritic gravel of no great depth or extent, while the adjoining plains are composed of cotton soil. The present water-supply is derived from wells which have been sunk, in some cases through solid rock, in others through gravel and the decomposed gneiss underlying it. The latter wells are naturally the chief sources of supply.

Three schemes were under consideration :—

(*a*) a boring at about 1½ miles to the west of the town with a view to finding water under artesian conditions in the local representatives of the Gondwana system ;

(*b*) utilisation of rivers ;

(*c*) a filtration gallery on a line of wells near the town.

The first of these was rejected on the ground that any water in the Gondwanas would not be under sufficient pressure to rise to the surface, whilst the cost of the second was considered prohibitive owing to the great distance to the nearest river of any size. The third scheme, which had been proposed by the Sanitary Engineer, Madras, although not regarded as completely satisfactory, was recommended as the only practicable method of increasing the water-supply.

Wolfram.

66. A report has been submitted by Mr. J. J. A. Page on the Wolfram of Mawchi in the Bawlake State, Karenni. This has already been dealt with under *Tin*, *q.v.*

GEOLOGICAL SURVEYS.

Assam.

67. During the field season of 1909-10, I examined a considerable area of hitherto unsurveyed territory in the Naga Hills between Kohima and the Disang river. The only rocks met with were members of the Disang, Tipam and Dihing series. Fossils, including an ammonite, were found for the first time in the Disang shales, and although they were unfortunately not determinable, they indicate that this series is at least in part pre-Tertiary. The

question has been dealt with in a paper published in these *Records*, Vol. XL, p. 283.

Burma.

Henzada District: Mr. M. Stuart.

68. Mr. Stuart was engaged throughout the field-season in mapping the Henzada district. In the General Report for 1909, attention was drawn to the fact that Mr. Stuart had observed an unconformity in Western Prome between the Kama clay and the overlying marine beds which had always been regarded as the upper part of the Pegu system. These marine beds Mr. Stuart included in the Irrawadi system under the name "Marine Irrawadi." In order to avoid confusing established nomenclature by an attempt to change the significance of the term "Irrawadi system," he has now adopted the name "Akauktaung series" for these marine beds, which he has found also in Henzada, where they are said to overlap the whole of the Upper and Lower Prome series and to rest directly on the Sitsayan shales. He regards them as of middle miocene age.

Central India and Rajputana.

Messrs. H. C. Jones, A. M. Heron and N. D. Daru.

69. The Central India and Rajputana party was constituted as in the margin, Mr. Middlemiss being unable to take the field personally on account of other work at headquarters.

Mr. H. C. Jones: Gwalior.

70. Mr. Jones continued his revision of the geology, and his investigation of the minerals, of the Gwalior State in those parts which lie to the west and south of the area begun last season (General Report for 1909, p. 112). He spent the greater part of the working season there, with the exception of the period, February 10th to April 4th, during which he was occupied with special enquiries (see page 70).

The re-examined area lies between latitudes 24°48′ and 26°40′ and longitudes 77°40′ and 78°30′. The rock groups do not differ from those summarised in last year's General Report and are :—

(1) Bundelkhand gneiss with quartz reefs and dolerite dykes,
(2) Upper Vindhyan sandstones and shales, lying unconformably above the gneisses and also above the Gwalior representatives of the Bijawars,

(3) Laterite, and

(4) Alluvium.

71. In his progress report Mr. Jones remarks on the general geology of the area being very similar to that of the area surveyed the season before. As before, also, he does not find anything to dispute in the original mapping of it as carried out by Messrs. Hacket and Kishen Singh, with the trifling exception of a few laterite hills which he found to be sandstone, in the Vindhyan area. He has, therefore, submitted no new maps, and the bulk of his report is descriptive of local occurrences of the rock systems mentioned above.

72. With the exception of some galena at Aindhar, which has already been referred to (*supra*, page 70), nothing of special economic interest was observed.

Mr. Heron: Alwar.

73. Except for a few weeks spent in investigating the effects of the Baluchistan earthquake (*supra*, p. 60) and a passing examination of the Kirana hills (pp. 71, 85), Punjab, Mr. Heron was engaged the whole season in continuing his work in Alwar State, the re-survey of which is now almost finished. As Mr. Heron proposes putting his results in memoir form at an early date, it will be sufficient here to note that his matured conclusions, after a second season, agree with his views briefly outlined in the last General Report (*Rec., Geol. Surv. India*, Vol. XL, p. 114) as to the true sequence of the formations, which in the main follow Hacket's original scheme as opposed to his (Hacket's) later interpretation of them.

At the same time there are many minor differences between the new and the old survey, and a much greater accuracy of delineation of the geology as displayed in Mr. Heron's new mapping, which, together with his photographs, sections, and detailed petrological studies, should afford material for a full descriptive account of this complicated region, whose geological interpretation has long remained uncertain.

Mr. Daru: Banswara.

74. Mr. Daru continued his survey of Banswara, which he practically completed, by filling in the remaining blanks on sheets 175, 176 and 177 of the Central India and Rajputana survey left over from last year, and with the addition of about 50 square miles in sheet 178.

Alluvium, Deccan Trap, Aravalli series and crystalline rocks continue as before throughout the region, and Mr. Daru's results may be briefly stated to be an extension into the new area of the mapping of the rock groups already begun by him.

The stratigraphical order of the members of the Aravalli series among themselves, tentatively adopted by Mr. Daru (see General Report for 1909, pp. 116-117) has, however, been finally rejected by him. He remarks in his Progress Report that limestones and even conglomerates have been intercalated at various horizons between the slates, etc., though a conglomerate band has often been found next to the supposed older crystalline rocks.

75. With regard to the problem of the intercalations of those crystalline rocks and the Aravallis referred to in last year's General Report (p. 118), he now writes in his last Progress Report:—

> "Although, in this report, following the arrangement of my preceding report, the crystalline intrusives and gneisses are placed as if belonging to an age prior to that of the Aravallis, the validity of such a course is open to dispute, especially with respect to this season's work. Intrusion has undoubtedly taken place into the Aravalli rocks, the intrusives have at times taken on gneissic characteristics, and have yielded boulders for the Aravalli boulder-beds; and these intrusives and gneisses are indistinguishable from those occupying larger but comparatively insignificant areas. Probably, therefore, the Aravallis and the intrusives and gneisses seen this season are coeval; some of the latter are undoubtedly subsequent to the Aravallis as can be seen from the way these have been disturbed. The same might, but with much less certainty, be said of the quartz-veins forming such a conspicuous feature of the Aravallis."

Central Provinces.

Chanda district: Mr. P. N. Datta.

76. The previously unsurveyed portion of Chanda district shown on Atlas sheet No. 73 was mapped geologically. It was found to consist chiefly of crystalline rocks, with a small patch of Vindhyans (conglomerate, sandstone, shale and limestone) in the extreme south-western corner. A red sandstone occurring at Markhunda on the left bank of the Wainganga is regarded as possibly of Gondwana age. The crystalline rocks comprise three groups:—

(*a*) a series of quartz, mica and hornblende-schists, with gneiss and argillite;

(*b*) gneissose granite; and

(*c*) diabase, granite and quartz.

The schistose gneisses (*a*) are regarded as older than either (*b*) or (*c*). They contain a bed of hematite which may be of economic value (*supra*, p. 71).

Punjab.

Kangra District: Dr. G. E. Pilgrim and Sub-Assistant Vinayak Rao.

77. Dr. G. E. Pilgrim has been engaged on a general geological survey of the Sub-Himalayan Tertiary zone between the river Ravi and Subathu, included for the most part in the districts of Kangra and Hoshiarpur, in the State of Chamba, and the Simla Hill States. He was accompanied during part of the time by Sub-Assistant M. Vinayak Rao, to whom was entrusted a portion of the mapping, and on whose work Dr. Pilgrim reports favourably.

Speaking broadly, the general geological and structural features follow those indicated by Medlicott on the map accompanying his memoir on this region (*Mem., Geol. Surv. Ind.*, III, pt. 2). A few modifications, however, have been found advisable. Medlicott omitted to differentiate between the Nahans (Lower Siwaliks) and the Siwaliks (Upper and Middle Siwaliks) to the north-west of the Sutlej, except along the innermost zone. It has now been found possible to separate the Nahans as far as the river Ravi, but, in the middle portion of this area lying between the river Beas and a line joining Una (31°29′ : 76°20′) to Mandi (31°43′ : 76°59′), only Upper and Middle Siwaliks are exposed from the Nahan boundary fault mapped by Medlicott right down to the plains. This absence of lower beds is due to the fact that the axes of the various folds dip both from the north-west as well as from the south-east towards this middle portion. As a result the upper beds have been removed by denudation from off the country to the north-west and south-west, thus exposing to view the older beds. The upper boundary of the Nahans (Lower Siwalik) is appropriately fixed by some very constant and very characteristic bands of red calcareous nodular clay, below which the sandstones are harder and, with the exception of a slightly pebbly zone much lower down in the series, contain no pebbles. This zone of red nodular clays is considered to belong to the uppermost part of the Lower Siwaliks; the fossils found in it—*Dinotherium, Amphicyon palæindicus, Giraffa, Dorcatherium,* *Hipparion* and *Hemimeryx pusillus* (?)—seem to point to a fauna which is more closely related to the Lower Siwaliks of Sind and Chenji in the Salt Range than to that of the typical Middle Siwaliks of the Salt Range. These nodular clays are very similar in appearance to those which are found in the Lower Siwaliks of the Salt Range. At Nurpur, certain pisolitic, pyritous beds associated with the red nodular clays resemble so closely the Lower Siwalik beds of the Kalawala Rau in the Siwalik Hills to the north of Saharanpur as to lead Dr. Pilgrim to correlate the two. At the same time, there is little doubt that they represent a higher horizon than the Chenji one, and must be put at the very top of the Lower Siwaliks. The fauna, when more fully known, will probably prove to be intermediate between that of the typical Lower Siwaliks of Chenji and that of the typical Middle Siwaliks of Dhok Pathan and Asnot.

78. The lowest member of Medlicott's Sirmur series, the Subathu, *sensu stricto*, is easily separated from the Dagshai-Kasauli group. Its fossils prove it to be of Khirthar age, and Dr. Pilgrim considers that stratigraphically as well as palæontologically, a great unconformity exists above this horizon.

79. There seems to be considerable probability that the Dagshai-Kasauli series passes up conformably into the Nahans. What Medlicott suggests to be an intermediate group (*Mem., Geol. Surv. Ind.*, III, Pt. 2, pp. 132, 133), though mapping it for the most part, but not universally, as Nahan, occurs along the base of the Nahan outcrop between Naini Devi (31°18′ : 76°36′) and Pinjor (30°44′ : 76°58′). Since these beds can be readily separated from the Nahans by their characteristic purple colour and by the greater hardness of the sandstones, while, on the contrary, their separation from the Dagshai-Kasauli group is a matter of extreme difficulty, it will most probably be found convenient to unite them with the latter series.

80. The pebbly sandstones above the Nahan nodular clays contain, north of Babhor (31°24′ : 76°26′), *Mastodon sivalensis*; they are harder than the typical Upper Siwaliks of the Pabbi Hills and elsewhere, and it is probable that a portion of the group above the red nodular clays represents the fossiliferous Middle Siwaliks of the Salt Range area. The thickness of this portion probably varies from some 500 feet to 5,000 feet. It is, however, a matter of extreme difficulty to fix the boundary between it and the Upper

Siwaliks, the position of such boundary can only be very approximate, and is based on the harder nature of the sandstones and on the occurrence of somewhat concretionary beds and calcareous bands. The Upper Siwaliks are often fossiliferous down to some 3,000 feet below the top. Near Pinjor (30°44′ : 76°58′) and between that place and Rupar (30°58′ : 76°36′), remains of the characteristic genera occur, amongst them being *Equus*, *Bos*, *Camelus*, *Elephas*, *Sivatherium* and *Merycopotamus*.

81. The so-called "Belaspur conglomerate," mapped by Medlicott as Nahan, is regarded by Dr. Pilgrim as Upper Siwalik, while the sandstone overlying it he believes to be Middle Siwalik. He also assigns an Upper Siwalik age to the thick beds of conglomerate which are met with at various places along the inner boundary of the Tertiary, faulted against the metamorphic beds. This conglomerate occurs in the hills below Dalhousie and continues almost as far as Dharmsala ; it is seen again between Mandi and Beijnath. In all these cases it has been mapped by Medlicott as Nahan.

82. The "Barsar" fault and the Nurpur fault are not on the same line of dislocation. The former fault has not been traced by Dr. Pilgrim appreciably farther to the north-west than the river Beas. The latter, which he regards as a branch of the "Gamber" fault, arises some little way to the north-west of Juwalamukhi (31°53′ : 76°23′). It seems to be cut off to the south-west by a cross fault which runs from Deira Gopipur through the Juwalamukhi range and probably extends past the so-called "Puthiar pronomotory" near the Neogal river. The fault mapped by Medlicott to the south-west of the Naini Devi range appears really to take its rise immediately east of Naini Devi (31°18′ : 76°36′) and to continue as a boundary fault between the Upper Siwaliks and the purple intermediate beds mapped by Medlicott as Nahan, but which Dr. Pilgrim prefers to include with the Dagshai-Kasauli series. This fault continues to the hills below Nahan, though often obscured by post-Tertiary deposits. The structure of the Naini Devi and Sola Singhi ridges was regarded by Medlicott as that of a syncline, but is regarded by Dr. Pilgrim rather as that of a much folded anticline.

Kashmir:
Mr. C. S. Middlemiss.

83. During the summer, Mr. Middlemiss continued his revision of the survey of Kashmir, and by detailed examination of the Sind valley up to the Zoji La and of parts of the Pir Panjal, added still further to the already large stock of valuable scientific information acquired

by him during the last few years. Mr. Middlemiss' work shows that Lydekker's interpretation of the age and structure of the Pir Panjal requires modification in many important respects, the most striking new fact being the absence of any pre-Carboniferous rocks and the continuation of the Lower Gondwana and Triassic beds along the north-eastern slopes of the range from Gulmarg to the Golabgarh Pass, where they cross the crest. The range is therefore composed of members of the Carbon-Trias sequence and constitutes a separate tectonic element, distinct, on the one hand, from the younger Sub-Himalayan and Nummulitic zone to the south-west and, on the other, from the older zone or zones, to the north-east, comprising large areas of rocks of pre-Carboniferous age.

Mr. Middlemiss' results are published in this number of the *Records*.

84. During the field-season 1909-1910, Mr. A. M. Heron visited the small groups of hills of the Jech and Rechna Doabs.

Kirana Hills: Mr. A. M. Heron.

There are in all four groups, *viz.*, at Kirana, at Chiniot, at Sangla, and at Shahkot. These hills are of peculiar interest as being at only a comparatively short distance from the fossiliferous belt of the Salt Range, to which, however, they appear to bear no stratigraphical or lithological resemblance. According to Mr. Heron, they consist of highly altered slates and quartzites, which stand almost vertical and strike from N.W. to S. E. On the southern part of the Kirana Hills, there are numerous bands of diabase and dark chert-like rocks. The general facies of the whole series of exposures is said to be somewhat similar to that of the Alwar and Ajabgarh divisions of the Delhi series.

DEVONIAN FOSSILS FROM CHITRAL, PERSIA, AFGHANISTAN AND THE HIMALAYAS. BY F. R. COWPER REED, M.A., F.G.S. (With Plates 7 and 8.)

INTRODUCTORY REMARKS.

FROM several widely separated localities in the Himalayas and the mountainous regions to the north-west of India Devonian fossils have been recorded from time to time, but no rich fauna like that from the Northern Shan States has yet been discovered. The fossils which have been collected have either been few or in poor preservation, so that their determination has been a matter of considerable difficulty or uncertainty, and the evidence of a Devonian age for the beds has been frequently unsatisfactory.

It is needless in this place to recapitulate the evidence of the occurrence of Devonian faunas in Eastern or South-eastern Asia, as this has been done by the author [1] recently and the lists of species quoted.

The following notes refer only to new and undescribed material collected by the Geological Survey of India and by others in Chitral, Persia, Afghanistan and the Himalayas within recent years.

(1) CHITRAL.

The fossils from Chitral were collected by Lieutenant I. H. Grant from the neighbourhood of the Baroghil Pass (approximately latitude 37°, longitude 73° 20′), and are preserved in a dark grey or black, compact or partly crystalline and occasionally fissile limestone. Some of them are nearly perfect, while others are very fragmentary.

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[1] Reed, Devonian Faunas, Northern Shan States, *Palæont. Ind.*, New Ser., Vol. II Mem. No. 5, 1908, pp. 146-154.

This is not the first series of Devonian fossils which has been brought home from Chitral, for in 1902 a collection of Devonian fossils from that country was described by Messrs. Hudleston and McMahon,[1] and I have had the privilege of examining them in the British Museum. But they undoubtedly belong to a higher horizon, and the evidence of the few brachiopods indicate an Upper Devonian age. The locality from which they were obtained was a cliff on the right bank of the Chitral River, immediately opposite Reshun, and their modé of preservation is different to that of these new ones from the Baroghil Pass. With regard to the latter, they indicate a Lower Devonian age, and the fauna consists of an intermixture of species possessing either Bohemian and North European affinities. A similar assemblage has been previously observed in the Lower Devonian of the Urals and Altai. The Bohemian element is predominant, and whether we refer the Zebingyi Beds of Burma to the Upper Silurian on account of their graptolites or to the Lower Devonian on account of the other members of the fauna, it must be remarked that here again in Chitral the Bohemian impress is conspicuous. These fossils have therefore a special interest from a zoo-geographical point of view.

The list of fossils from the Baroghil Pass is as follows :—

Proetus chitralensis sp. nov.
Polytropis Guilleri (Oehl.) ?
Pterinea sp.
Spirifer primævus Stein. var.
  „ cf. *robustus* Barr.
  „ aff. *canaliferus* Valenc.
  „ sp.
Athyris cf. *subconcentrica* D'Arch and Vern.
Pentamerus (*Sieberella*) *Sieberi* Von Buch.
Rhynchonella (*Uncinulus*) cf. *Bureaui* Barrois.
Liorhynchus sp.
Orthis cf. *præcursor* Barr. var. *sulcata* Scup.
Stropheodonta Phillipsi Barr.
  „ ? sp.
Orthothetes hipponyx Schnur.
  „ ? sp.

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[1] Hudleston and McMahon, *Geol. Magazine*, Dec. IV, Vol. IX, 1902, pp. 3-8 and 49-58, pls. II and III.

Chonetes aff. *embryo* Barr.
Productella ? sp.
Fenestella sp.
Thamnicella ? sp.
Striatopora cf. *vermicularis* McCoy.
Crinoid stems.

Notes on some of the Fossils.

PROETUS CHITRALENSIS sp. nov. Pl. 7, figs. 1-6.

There are several nearly perfect pygidia of a large species of *Proetus*, with sufficient fragments of the head-shield and thorax to enable us to define a new species. All the specimens occur in the same kind of matrix, a black limestone, and evidently belong to the same form.

The pygidium (figs. 1-4) is semicircular in outline and moderately convex. The axis is broad, being about one-third the width of the pygidium, gently convex, subconical, slowly tapering to a blunt rounded extremity reaching the inner edge of the border. The axis consists of 10-11 segments, and is annulated to its tip ; the rings are rounded with deep furrows between them and possess indistinctly defined lateral nodules behind which the furrows are rather weaker and bend slightly back ; a small transverse pit or short incomplete furrow slightly notches the posterior edge of each ring and marks off imperfectly each lateral nodule from the rest of the ring.

The pleural lobes of the pygidium are not wider than the axis anteriorly, from which they are marked off by narrow axial furrows, and are arched down gently at the fulcrum which is situated at rather less than half the length of the pleuræ; there are 8-9 pleuræ, ending abruptly at the inner edge of the border and slightly bent back at the fulcrum; each pleura is divided into two unequal parts by a fine weak longitudinal furrow, the anterior half of the pleura being narrow and flattened and the posterior part two or three times as wide and more elevated and convex.

The border of the pygidium is rounded, somewhat swollen and of uniform width; it is not marked off from the pleural lobes by a definite marginal furrow, but the pleuræ and their furrows end abruptly against it.

The surface of the shell is sparsely pitted; the axial rings have their posterior edge usually roughened or even slightly fimbriated, and their surface is ornamented by small short arched imbricating striæ just inside the lateral nodules and along the posterior portion. The pleuræ are marked with smaller and less distinct imbrications on their posterior half which also has a roughened edge.

One imperfect free cheek (fig. 5) preserves most of its anterior outline, and by its unbroken anterior inner edge we see that the facial suture in front of the eye is bent forwards and strongly outwards in a weak sigmoidal curve nearly at right angles to the general trend of the lateral margin. The genal angle is rather broken, so that we cannot see clearly if it was pointed or obtuse, but the lateral and posterior edges of the cheek are seen to be inclined to each other at about 75°, and there is a broad rounded rather prominent raised border surrounding it, marked with a few strong regularly concentric and rather widely spaced thread-like raised lines and separated from the rest of the cheek by a sharply impressed marginal furrow. The general surface of the free cheek is much elevated and swollen except round the eye where a rather deep and broad sub-ocular groove curves forward outside the eye from the neck-furrow, extending fully three-fourths the length of the cheek. The eye itself is borne on a steep plinth inside it and is large and semicircular in shape, so far as can be seen. The lower slopes of the free cheek are marked by a few short oblique imbricating striæ, but otherwise the shell seems smooth. In another specimen (fig. 6) the posterior part of the cheek is better seen.

Fragments of the thorax are recognisable associated with the pygidia, etc. and allow us to determine that the axis was broad (nearly one-third the width of the thorax), with the body-rings of the usual type. The pleuræ have the fulcrum situated at rather less than half their length, and a strong submedian furrow runs along them. The extremities are not well preserved in any case, but appear to have been obtusely and obliquely truncate.

Dimensions.

Length of pygidium	22·0 mm.
Width of ditto	32·0 mm.
„ of axis	13·0 mm.
Length of axis	19·0 mm.
Width of border	3·0—3·5 mm.

Affinities.—This species is allied to *Pr. bohemicus* Barr.,[1] but differs by the posterior half of the pleuræ of the pygidium being more swollen, and by the border of the head-shield being concentrically striated above as well as laterally and below. The ornamentation of the shell is also different. The relative size and shape of the axis, and the lateral nodules of the axial rings with the pits marking them off are in close agreement. The characters of the border of the pygidium are similar, and the free cheek with its peculiar depressed curved area outside the eye precisely corresponds with the Bohemian species. Tschernyschew[2] has described the allied *Pr. Oehlerti* from the Altai in Lower Devonian beds, and *Pr. uralicus*[3] from the same horizon on the eastern slopes of the Urals. In the characters of the cephalic border, genal angle and free cheek, and also in the general features of the pygidium, the latter species seems to be somewhat closely related to the new Chitral form.

POLYTROPIS GUILLERI (Oehlert)?

A portion of the basal whorl of a *Cyclonema*-like shell exhibits features which lead us to refer it with much probability to the species described by Oehlert[4] as *Turbo Guilleri.* The characteristic ornamentation of this species is clearly seen, and the whorl agrees in shape with the figures of this Lower Devonian gasteropod. Frech[5] has figured it from the black gasteropod limestone of the Carnic Alps, and according to this author it is identical with Barrande's *Turbo laetus* from the limestone of Konieprus. Tschernyschew[6] has found this shell on the west slopes of the Urals.

PTERINEA sp. Pl. 7, fig. 7.

There is one imperfect right valve of a species of *Pterinea* of which only the body of the shell is well preserved, but sufficient has been freed from matrix to determine the genus and give a fairly full description. The body is high, triangular, slightly oblique and curved back moderately convex, and anteriorly it falls down steeply to the small anterior ear, which is acutely pointed, triangular, flattened and depressed, with a concave lower edge extending down the front of the body for about one-third its height. The beak is broken, but apparently was small, sharp, slightly bent back and rose a little above the hinge-line. The posterior part of the shell is not well preserved, but a straight hinge-line, with a flattened depressed triangular large ear below, is visible; the posterior margin of the shell is apparently slightly excavated, and the body sinks down gradually to the posterior ear. There are about twelve strong equidistant rounded ribs on the body; they radiate from the beak, swelling out at fairly regular intervals into small nodes, and between the ribs are smooth flattened interspaces of somewhat greater width. The anterior ear has upon it only strong concentric striæ following the lower (anterior) edge, and the posterior ear seems to be similarly ornamented and devoid of radiating ribs.

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[1] Barrande, *Syst. Silur. Boh.*, I, Trilob. p. 452, pl. 16, figs. 1-15.

[2] Tschernyschew, *Verh. russ. kais. min. Gesell.* Ser. 2, Vol. 30, 1893, p. 12, t. II, figs. 7, 8.

[3] Tschernyschew, *Mem. Com. Géol. St. Petersburg*, Vol. IV, No. 3, 1893, pp. 11 and 78, t. 1, figs. 1-3.

[4] Oehlert, *Mem. Soc. Geol. France*, ser. 3, Vol. II, 1881, p. 7, pl. 1, fig. 4; Barrois, Faune d' Erbray (*Mem. Soc. Geol. Nord*, III, 1889), p. 220, pl. xv, fig. 12.

[5] Frech, *Zeitschr. deut. Geol. Gesell.*, xlvi, 1894, p. 464, pl. XXXV, figs. 1*a*-1*d*.

[6] Tschernyschew, Fauna West Abh. Urals (*Mem. Com. Russ.* Vol. III, No. 1, 885) t. iv, fig. 37.

Dimensions (approximate).

Height of body	7·0 mm.
Length (along hinge line)	6·5 mm.

It seems to be probable that this species belongs to the same group as *Pt. bellula* Whidb.[1] and its allies.

SPIRIFER aff. PRIMÆVUS Steininger. Pl. 7, fig. 9.

There are three specimens (K 9·26, 27, 28) of a large coarsely ribbed species of *Spirifer*; two are examples of the pedicle valve and one of the brachial valve in the condition of an internal cast; but none are perfect or well preserved.

The pedicle-valve in the best specimen measures about 40 mm. in width and about 23 mm. in length, and is triangular and transverse in outline; it is moderately convex, most so in its median portion, but laterally it is somewhat flattened; the beak is prominent, moderately high and incurved, rising considerably above the hinge-line, so that there must have been a rather large triangular and steeply inclined or vertical hinge-area below it. The hinge-line is straight and forms the widest part of the shell; the lateral angles are acute, but not produced. A deep angular median sinus is present, widening regularly (but rather slowly) towards the front margin, and has smooth sides meeting in the middle at a sharp angle; a sharp angular specially prominent plication borders the sinus on each side and is continued with a slight increase of height to the front margin; on each side are 5 or 6 regular simple subangular plications of equal size increasing in strength towards the margin and separated by strong subangular grooves equal in width and depth to the plications.

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[1] Whidborne, *Devon. Fauna S. England,* (*Palæont. Soc.*), Vol. II, 1892, p. 57, pl. IV, fig. 11.

The other specimen of a pedicle-valve is less perfect and has been crushed, but exhibits the same characters.

The internal cast of the brachial valve is imperfect, but shows the deeply impressed elongated adductor scars separated by a weak median ridge. Some of the plications of the surface with the same characters as those on the opposite valve are preserved on fragments of the shell attached to the cast.

As regards the affinities and specific position of this species of *Spirifer* we notice that in the general shape of the shell, character and small number of the plications, smooth angular sinus and stronger bordering folds there is a great resemblance to *Sp. primævus* Stein. As Drevermann[1] has pointed out, there is a large number of species closely allied to *Sp. primævus* or even included in it by some palæontologists, and this whole series of forms is characteristic of the Lower Devonian. Amongst them may be mentioned *Sp. Decheni* Kayser,[2] *Sp. hystericus* Schl.,[3] *Sp. subhystericus* Scupin[4] and *Sp. excavatus* Kayser (pars),[5] all of which possess many features in common with this Chitral shell.

We may draw attention to a certain resemblance between our shells and Tschernyschew's *Sp. nobilis* Barrande, var. *irbitensis*,[6] from the Lower Devonian of the Urals; but the latter has not pointed cardinal angles and the ribs seem to be more rounded and the whole shell less transverse. The sinus also does not appear to be decidedly angular.

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[1] Drevermann, Fauna Sc., Soh. *Palæontograph.*, Bd. L, 1904, p. 246, t. XXIX, figs. 1-7.

[2] Kayser, *Alt. Dev. Ablag. Harzes*, p. 165, t. XXII, figs. 1, 2.

[3] Barrois, *Mem. Soc. Geol. Nord*, II, 1882, p. 250, pl. IX, figs. 11 *a*, *b*.

[4] Scupin, Spirif. Deutchl., *Palæont. Abhandl.* N. S. Bd. IV, Heft 3, p. 15, t. I, figs. 9-10.

[5] Kayser, *op. cit.* p. 172, t. XXV, fig. 22 (cet. excl.).

[6] Tschernyschew, *Mem. Com. Geol. St. Petersburg*, Vol. IV, pt. 3, pp. 55 and 170, pl. VIII, figs. 1-5.

SPIRIFER cf. ROBUSTUS Barrande. Pl. 7, figs. 8, 8*a*.

There is one pedicle-valve (K 9·9) of a smooth species of *Spirifer* which at first sight recalls *Sp. glaber* Mart., *Sp. lineatus* Mart. and their allies. It measures about 28 mm. in width and 23 mm. in length, and is strongly convex and rounded with originally a subcircular outline, though the anterior margin of the specimen has been somewhat broken. The beak is large, swollen, prominent and rounded, and rises rather high above the hinge-line over which it is strongly incurved. The hinge-area, which is not exposed to view, must have been small, and the hinge-line is straight, horizontal, nearly the maximum width of the shell and has obtuse cardinal angles. The surface of the valve is smooth, but it is marked down the centre by a strong, though narrow, sinus, extending the whole way from the beak to the anterior margin as a definite and rather deep rounded channel with nearly parallel sides and a width of about 3-4 mm. for more than half its length but expands a little and flattens towards the front. Faint traces of delicate longitudinal striæ are visible in the floor of the sinus. The lateral halves of the shell rise up on each side of the sinus rather suddenly as rounded simple somewhat swollen lobes, arching down to the margins.

With regard to the affinities of this shell the straight hinge-line, cardinal angles and large swollen imperforate beak forbid us referring it to the genus *Athyris*, though at first sight it seems to resemble some examples of *A. undata* Defr., and it is to the genus *Spirifer* that we must assign it. Barrande's *Sp. robustus* [1] from the Lower Devonian of Bohemia may especially be compared, and *Sp. superstes* Barrande [2] is also very similar. Tschernyschew [3] has figured examples of *Sp. robustus* from the Lower Devonian of the eastern slopes of the Urals, and his smaller specimen appears to bear a great resemblance to our shell.

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[1] Barrande, *Haidinger's Naturwiss. Abhandl.* II, 1848, p. 162, pl. XV, fig. 1.

[2] *Ibid.* p. 164, pl. XVII, fig. 8; Scupin, *Zeitschr. deut. geol. Gesell.*, LVIII, 1906, p. 286, t. XVI, fig. 12*a*.

[3] Tschernyschew, *Mem. Com. Geol. St. Petersb.* Vol. IV, No. 3, 1893, pp. 48 and 167, t. VI. figs. 1*a-d*.

SPIRIFER aff. CANALIFERUS Valenciennes?

One crushed and imperfect internal cast (K 9·19) of pedicle-valve of a species of *Spirifer*, replaced by beekite, deserves notice, as it indicates a distinct species. In shape the shell was probably rounded or subquadrate, but the anterior margin is so broken that it has a bilobed appearance. The cardinal angles are rectangular or obtuse; the hinge-line is straight and apparently just equal to the width of the shell. The beak is large, high, swollen and incurved. The general surface of the shell is convex, but it is divided into two rounded swollen lobes by a shallow sinus, which has been narrowed and deepened in this specimen by lateral compression; a narrow median channel seems to mark the middle of the sinus, but the sides are ribbed like the lobes of the shell into which they pass imperceptibly without any angular edges. The swollen lobes each bear 10 or 12 simple low rounded or somewhat flattened ribs of equal size and set close together. The length of the valve is about 30 mm., and the width about 40 mm.

In ribbing and shape the shell somewhat resembles the American species *Sp. arenosus* Conr., and it may be allied to the European *Sp. canaliferus* Valenciennes,[1] but it is in too imperfect a condition to trace its relationships any closer. The shell from Turkestan described by Romanowski as *Sp. crassus*[2] is preserved in the same way with the peculiar concentric "beekite" structure.

SPIRIFER sp.

The interior of a somewhat broken brachial valve (K 9·8) of a species of *Spirifer* has much the same shape and general characters of Gosselet's "attenuate group" of *Sp. Verneuili*, but certain minor differences are revealed on a close examination. The shell has a transversely triangular outline, with somewhat pointed lateral angles, but these are rather imperfect. On each side of the median fold there are 20 to 25 small rounded ribs, separated by equal interspaces, and they are simple straight, equidistant and of equal size. A somewhat deeper groove bounds the rounded fold on each side; and down the middle of the fold runs a similar narrow rather deep groove with 4 or 5 equal ribs on each side; these ribs have the same size and character as those on the lobes, but the second and third seem to arise by dichotomy of one rib at half its length. Our shell measures about 35 mm. in width and 15 mm. in length. We may perhaps compare this shell with *Sp. Trigeri* De Vern., of which Barrois[1] says that the ribs on the fold are like those on the lobes and rarely dichotomise, herein differing from *Sp. Verneuili.* The transverse forms of this species from the beds in Asturias correlated with the Upper Coblenzian and Lower Eifelian, which are figured by Barrois (*op. cit.*), may especially be mentioned in connection with our Chitral fossil, but they have not the median groove on the fold.

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[1] Schnur, Brach. Eifel, p. 206, pl. XXXV, figs. 5*a*-*e*.

[2] Romanowski, *Mater. Geol. Turkestan*, Lief. I, 1880, p. 105, pl. XV, figs. 6*a*, *b*.

ATHYRIS cf. SUBCONCENTRICA D'Archiac and De Verneuil.

One small pedicle-valve (K 9·36) of a shell referable to *Athyris* shows the general shape and concentric ornamentation of *A. subconcentrica* D'Arch. and de Vern.,[2] and it also resembles *A. undata* Defr.,[3] but the median sinus in our specimen is less defined and narrower than in the latter, and especially resembles the examples of *A. subconcentrica* described and figured by Barrois[4] from Erbray.

PENTAMERUS (SIEBERELLA) SIEBERI Von Buch. Pl. 7, fig. 10.

There is one large and nearly perfect example of *Pentamerus* (*Sieberella*) *Sieberi,* measuring about 42 mm. in width and 28 mm. in length. The brachial valve which is best exposed, possesses the usual shape and characters of this well marked species; there are five plications present in the broad sinus and six or seven on each side of it; the plications are sharp, angular and continuous from the beak to the margin and are equidistant and all of equal size except those bounding the sinus on each side which are slightly larger. The median septum extends to about half the length of the valve, arising at the point where the crural plates unite in a sharp V at rather more than one-fourth the length of the valve.

This species is a characteristic Lower Devonian form in Bohemia,[5] but also occurs on the same horizon in the Harz,[1] at Erbray,[2] in the Carnic Alps[3] and probably in Siberia, for it seems as if Von Peetz's[4] *P. acutolobatus* Sandb. should be referred to this species. Hall and Clarke[5] following Oehlert, have chosen it as the type of the subgenus *Sieberella.*

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[1] Barrois, Assises Asturiennes, *Mem Soc. Geol Nord,* II, 1882, p. 258, pl. X., fig. 6.

[2] De Verneuil, *Bull. Soc. Geol. France,* Vol. II, 1845, p. 463, pl. XIV, fig. 1.

[3] Oehlert, *Ann. Sci. Geol.* XIX, 1886, p. 32, pl. III, figs. 1-20.

[4] Barrois, Faune d'Erbray, (*Mem. Soc. Geol. Nord,* III, 1889), p. 114, pl. VII, fig. 4.

Barrande, *Haidinger's Naturw. Abhandl.* I, 1847, p. 465, t. XII, figs. 1, 2.

RHYNCHONELLA (UNCINULUS) cf. BUREAUI Barrois.

The peculiar species known as *Rh. Bureaui* Barrois,[6] which is closely allied to *Rh. orbignyana* (De Vern.),[7] is chiefly marked by the presence of a distinct saddle or fold in the middle of the sinus on the pedicle-valve. One interior of a small pedicle-valve, 6 mm. long, (K 9·34) in the collection from Chitral, exhibits this feature and in ribbing and shape also appears to resemble *Rh. Bureaui.* Scupin[8] has described the species from the Eastern Alps.

LIORHYNCHUS sp.

A fragment of a brachial valve of a large rhynchonelloid or pentameroid shell (K 9·23) shows the median fold composed of four equal subangular plications arising a little in front of the beak and continued with gradually increasing strength to the anterior margin. The fold rises with steep high sides from the lateral lobes, and at the base of the slope on each side is a single straight weaker plication, but the rest of the lateral lobes seems smooth and devoid of plications. The valve has an elongated-oval or slightly subpentagonal shape, so far as can be seen, and is widest across the middle; a coarse concentric lineation zigzagging over the plications is present. The valve has been somewhat flattened by pressure, but must have been moderately convex in its original state.

Dimensions.—Length 25 mm., width 22 mm. (approx.).

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[1] Kayser, Aelt. Devon. Ablag. Harzes, 1878, p. 158, t. XXVII, figs. 5-9, 13.

[2] Barrois, Faune d'Erbray, p. 77, pl. v, fig. 1.

[3] Scupin, *Zeitsch. deut. geol. Gesell.*, LVIII, 1906, p. 254, t. XV, fig. 4

[4] Von Peetz, *Beitr. Kennt. devon. Schicht. Kusnetzk,* 1901, p. 164, t. V, figs. 14*a*, *b*.

[5] Hall and Clarke, *Palæont. N. Y.*, VIII, Brach. II, p 240.

[6] Barrois, Faune d'Erbray, p. 98, pl. V, fig 8.

[7] De Verneuil, *Bull. Soc. Geol. France* ser. 2, Vol. VII, 1850, p. 175, pl. III, figs. 10*a-c*. Barrois, *Mem. Soc. Geol. du Nord,* Vol. II, 1882, p. 265, pl. XI, fig 1.

[8] Scupin, *Zeitschr. deut. geol. Gesell.*, LVIII, 1906, p. 248, t. XIV, figs. 4 7, 9.

This shell may be referred to the genus *Liorhynchus* as defined by Hall and Clarke,[1] and it seems to resemble *L. globuliformis* Vanuxem,[2] in its general shape and plication. Probably the English species *Rhynchonella protracta* Phill.[3] is allied.

ORTHIS cf. PRÆCURSOR Barrande, var. SULCATA Scupin.

Two fairly perfect examples (K 9·34) of the brachial valve of a small *Orthis*, one of which is an interior measuring 10·5 mm. long, appear to possess the characters of the shell described by Scupin[4] as a variety (var. *sulcata*) of Barrande's species *Orthis præcursor*.[5] The shape of the valve, the median longitudinal depression and the ornamentation seem to agree closely.

STROPHEODONTA PHILLIPSI Barrande.

Several specimens of a strophomenoid shell (K 9·20, K 9·33), exhibiting both brachial and pedicle-valves, which occur in the collection, may be referred without hesitation to this species, for examples of it named by Barrande have been carefully compared with them. All are of small size, measuring only from 15 to 18 mm. in width. The form illustrated by Scupin from the Eastern Alps under this name[6] agrees with these Chitral specimens in appearance. It is quite possible, as Scupin suggests, that Phillip's *Str. interstrialis* is the same species, but at present it is desirable to keep them apart. Most of our specimens are brachial valves, only one good example of a pedicle-valve having been recognised.

STROPHEODONTA sp. ?

There is one fragment (K 9·10) of the cardinal region and muscular area of a large strophomenoid shell which may be probably referred to the genus *Stropheodonta*, but it is certainly distinct from *Str. Phillipsi*. In shape and characters, so far as they are distinguishable, this large shell, which must have measured when perfect 30 to 35 mm. in length, suggests some species like *Stroph. herculea* Drevermann.[1]

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[1] Hall and Clarke, *Palæont. N. Y.* Vol. VIII, Brach. II, p. 193.

[2] *Ibid.* pl. LIX, figs. 23-27.

[3] Davidson, *Mon. Brit. Brach.* V. Suppl. p. 41, pl. II, figs. 17, 17*a*.

[4] Scupin, *op. cit.* p. 221, t. XII, fig. 6.

[5] Barrande, *Syst. Silur. Bohême*, Vol. V, 1879, pl. LVIII, fig. 3.

[6] Scupin, *op. cit.* p. 216, t. XI, figs. 1, 2.

ORTHOTHETES HIPPONYX (Schnur).

Several fragments (K 9·34) of valves of a large flattened shell may be referred without hesitation to the Lower Devonian representative of *Orthothetes umbraculum* which Oehlert[2] has shown to be Schnur's *O. hipponyx*[3] and to possess sufficient distinctive characters to separate it from the well-known Middle Devonian species. The characteristic ribbing and ornamentation can be seen on all our Chitral specimens, and one also shows the large scar of the divaricator muscles in the pedicle-valve.

ORTHOTHETES ? sp.

A portion of a strophomenoid shell of doubtful generic position (K 9·15) is worth mentioning because of its distinctive ornamentation. It probably belongs to *Orthothetes, Streptorhynchus* or *Derbya.* The valve appears to have been semielliptical in outline and to have measured about 20 mm. in width and 13-15 mm. in length; the hinge-line is straight and rather less than the greatest width of the valve, and the cardinal angles were probably obtuse. The greater part of the valve is nearly flat with a very gentle convexity near the beak which seems to have been small and non-projecting and quite inconspicuous, as in *Stroph. interstrialis;* the margins of the valve are bent up rather irregularly, and there are traces of low irregular and weak rounded concentric corrugations just inside this geniculation. The surface of the valve is ornamented with numerous coarse rounded somewhat irregular ribs increasing a little in size towards the margins and inclined to be nodular; the majority of these ribs are continuous and roughly equidistant, but are rather irregularly developed, and shorter similar ribs are occasionally intercalated at about one-third to one-half the length of the primaries. There are in all about 40 to 50 ribs round the margin, and between them there are 2 to 4 delicate thread-like decussated longitudinal striæ. Some English specimens which have been referred to

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[1] Drevermann, *Palæontographica,* L. No. 6, 1904, p. 276, t. XXXII, figs. 5-6.

[2] Oehlert, *Bull. Soc. Geol. France.* Ser. 3, Vol. XXIV, 1896, p. 856, pl. XXVII, figs. 9-11.

[3] Schnur, Brach. Eifel, p. 217, t. XL, fig. 1.

Orthothetes crenistria, have closely similar characters, but the true position of our Chitral shell is uncertain.

CHONETES aff. EMBRYO Barrande. Pl. 7, fig. 11.

A small species of *Chonetes* is represented by two pedicle-valves, the best preserved of which measures about 7 mm. long. In shape it is like *Ch. minuta* Goldf.,[1] but there are several small points of difference. The shell is transversely semioval, about one and a half times as wide as long, widest along the hinge-line, with the cardinal angles slightly auriculate and rather pointed at about 60°—70°. The general surface of the valve is strongly convex, arched down in front, but the subtriangular ears are somewhat depressed, horizontally extended and flattened. The beak is obtuse, swollen, and curved over the hinge-line. There are about sixteen simple low rounded ribs of equal size placed close together and proceeding from the beak to the anterior margin without division or intercalation; there are no ribs on the ears which are smooth.

This shell differs from *Ch. minuta* Goldf. by the smooth and rather more pointed ears, and especially by the non-division and regularity of the ribs. *Ch. Davousti* Oehlert,[2] and *Ch. Phillipsi* Dav.[3] are both allied, but neither has smooth ears. *Ch. embryo* Barr.[4] agrees with our form more intimately not only in its general characters but also in the closer position and ordinary simplicity of the ribs separated by narrower interspaces than in *Ch. minuta,* as Scupin[5] has pointed out. It is a recognised Lower Devonian species.

PRODUCTELLA ? sp. Pl. 7, fig. 12.

The genus *Productella* or *Strophalosia* is apparently represented by one specimen (K 9·34) from Chitral. The valve is transversely subquadrate in shape measuring 13 mm. long and 22 mm. wide; the visceral disc is gently convex, but the lateral cardinal portions are flattened and slightly bent up so as to form triangular ears obscurely marked off from the disc by shallow oblique depressions. The anterior marginal third of the shell is suddenly arched down. The hinge-line is straight and equal to the maximum width of the shell, while the cardinal angles are almost rectangular and scarcely produced. The beak is not well exposed, but was obviously small, not swollen, and inconspicuous. The surface of the shell is marked by 10 or 11 regularly concentric strong rounded corrugations closely placed and of subequal size, continued on to the ears and meeting the hinge-line at right angles. A few small inconspicuous pustules are situated on the rugæ of the disc, but on the portion of the shell which is arched down the corrugations are obsolete and the pustules are large and elongated into 9 or 10 somewhat marked longitudinal ridges as in *Strophalosia poyangensis* Kayser[1] from the Upper Carboniferous of China, and *Aulosteges tibeticus* Diener,[2] from the Permo-Carboniferous of Chitichun. The true relations of this form are uncertain.

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[1] Schnur, Brach. Eifel, p. 227, pl. XLIII, fig. 3.

[2] Oehlert, *Ann. Sc. Geol.* XIX. 1886, p. 66, pl. IV, figs. 17-21.

[3] Davidson, *Mon. Brit. Brach.* Suppl. V, p. 54, pl. III, figs. 23, 23*a*.

[4] Barrande, *Haidingers Naturwiss. Abhandl.* II, 1848, p. 248, t. XXIII, fig. 19.

[5] Scupin, *Zeitschr deut. Geol. Gesell.* LVIII, 1906, p. 215, t. XI, figs. 7-8.

(2) PERSIA.

A small collection of fossils was made by Mr. Griesbach in 1886[3] from the hills south and south-east of Raband, Mashhad district, Khorasan. They are preserved in a very fossiliferous somewhat rotten flaggy greyish limestone, crowded with examples of a variety of *Sp. Verneuili.* We are already acquainted with a fairly abundant Upper Devonian fauna from Persia, for Frech and Arthaber[4] have described a series of fossils of this age from the Alburs range in Northern Persia, while Frech[5] has recorded others from Turub, and Stahl[6] has mentioned some from south of Abdid (approx. long. 57°E., lat. 31° 10′). In all these cases *Sp. Verneuili* or one of its varieties is recorded.

The list of fossils in this collection made by Mr. Griesbach from Khorasan is as follows :—

(*a*) Hills south of Raband, Mashhad district.
Cyathophyllum cf. *hexagonum* Goldf.
Spirifer Verneuili var. nov. *persica*.

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[1] Kayser in R'chthofen's ' China,' IV, p. 190, pl. XXVIII, fig. 9

[2] Diener, Palæont. Ind. Ser. XV, Vol. I, pt. 3, pp. 35, l. V, figs. 3-6.

[3] Griesbach, *Records, Geol. Surv. India,* Vol. XX, pt. 2, 1887, pp. 93-103, map.

[4] Frech and Arthaber, *Beitr. Palæont. Geol. Oester. Ungarns u d. Orients,* Vol. XXI, Heft 4, 1900, pp. 192-198.

[5] Frech, *Neues Jahrb. f. Mineral* II, 1895, pp. 59-62

[6] Stahl, Zur Geol. Persiens, *Petermann's Mitteil. Ergänzungsheft,* No. 122. 1897, pp. 63, 68.

Spirifer sp.
Stropheodonta interstrialis Phill.
Strophalosia ? sp.

(*b*) Hills south-east of Raband, Mashhad district.
Spirifer Verneuili var. nov. *persica.*
Stropheodonta interstrialis Phill.
Strophalosia ? sp.
Rhynchonella ? sp.

This fauna appears to indicate an Upper Devonian age for the beds.

Notes on some of the Fossils.

SPIRIFER VERNEUILI Murchison, var. nov. *persica.* Pl. 8, figs. 3, 4, 5.

This highly variable species is abundantly represented in the collections from the two localities in Khorasan by a form belonging to Gosselet's[1] group *attenuati* which is characterised by its transverse spindle-like form, the wings being much extended and terminating in points and the width having the proportion to the length intermediate between 3 and 2·50. To the same group may be referred the shells from the Upper Devonian of Chitral described by Hudleston and McMahon[2] as *Sp. extensus* Sowerby. In spite of the great variability of the species, *Sp. Verneuili,* the varieties of which have frequently been treated as of specific value and distinguished by separate names, it seems advisable to follow Davidson[3] and Gosselet (*op. cit*) in uniting them all, though the extreme ends of the series possess a most distinct appearance. Gosselet (*op. cit.* p. 8) has pointed out that the most important and special character possessed by all the members of the species *Sp. Verneuili* is that the ribs on the wings are simple, while those on the fold and in the sinus are bifurcated and finer.

In our specimens there are certain peculiarities of detail which suggest a distinct variety; the first rib on each side of the sinus in the pedicle-valve is rather larger, thicker and more prominent than the others on the wings, while in the sinus itself there are usually only 6 or 7 ribs of which only two of the lateral ones are continuous from the beak to the margin, the others being shorter and intercalated and not obviously formed by division; in some specimens one of these ribs is clearly median and rather broader and longer, but all the ribs in the sinus are finer than those on the wings. Moreover, in the brachial valve of young individuals there is on each side of the fold a distinctly wider and deeper groove than any between the lateral ribs, and the fold itself bears a pair of continuous outside ribs, not finer than those on the wings with a group of three shorter smaller ones in the middle. There are from 18 to 22 simple continuous ribs on each wing. None of our specimens are large; some of the shells measure 30 mm. in width, but most are smaller.

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[1] Gosselet, Ét. Var. Spirifer Verneuili; *Mem. Soc. Geol. Nord.*, IV, No. 1, 1894, p. 14, pl. II, figs. 6, 8, 9; pl. III, figs. 15, 16; pl. IV, fig. 19.

[2] Hudleston and McMahon, *Geol. Magazine,* Dec. IV, Vol. IX, 1902, p. 53, pl. II, figs. 8*a-d.*

[3] Davidson, *Mon. Brit. Brach.*, Vol. III, pp. 23-26

It will be seen by the above remarks that the ribs on the fold and sinus are fewer than in ordinary adult examples of *Sp. Verneuili* and rather differently developed, but in these respects they resemble the shells figured by Gosselet as young individuals of the "first age" from the Frasnian (*op. cit.* pl. V, figs. 44, 45 and 49, p. 37), though our specimens have the transversely extended shape of adult members of the *attenuati* group. We may accordingly designate this variety by the distinctive name *persica*. In the case of the specimens from Chitral referred by Hudleston and McMahon to *Sp. extensus* Sowerby, the ribs on the wings are separated by wider interspaces than in our variety, and those on the fold and in the sinus are very faint and much finer, while there is also no specially strong rib on each side of the sinus nor noticeably deeper groove on each side of the fold. Some of Davidson's specimens of *Sp. disjunctus* from Kwangsi[1] have these lateral grooves alongside of the fold as markedly developed as in our variety, but the ribs on the fold itself are not precisely similar, and all the ribs bear sharp tubercles and longitudinal striæ. The separation of these Persian examples of *Spirifer* from the Carboniferous species *Sp. attenuatus* Sowerby, is only evident after minute comparison, but the differences between *Sp. Verneuili* and the latter have been pointed out by many palæontologists and the chief features are here recognisable.

STROPHALOSIA ? sp. Pl. 8, fig. 6.

The Khorasan examples of a species of *Strophalosia* or *Productus* are characterised by a peculiar development of the concentric rugæ. It is noticeable that these occasionally divide and sweep round the blunt pustules, while in other cases they swell out to form the base. The rugæ are narrow, rounded, closely set and gently zigzag or undulated, and their width and course are determined by the position of the pustules which are arranged in a roughly quincunx manner. Our shell resembles Phillips' *Leptæna membranacea*[1] in the course of the rugæ, but they are much coarser and fewer in number, and the development of the pustules agrees more with that in some examples of *Stroph. productoides* (Murch.) as figured by Davidson.[2] Whidborne[3] was not sure if *Lept. membranacea* should be included in *Stroph. productoides.* The sculpture and ornamentation, however, much more resemble those of the Carboniferous *Productus nystianus* (De Kon.)[4] of which a variety has been described by Kayser[5] from China. The apparent relationship of the Khorasan shell to this Carboniferous species caused me to hesitate not only with regard to its generic position, but also with regard to the age of the beds in which it occurs. But the presence of *Stropheodonta interstrialis* and the Devonian affinities of the species of *Spirifer* seem sufficient to decide the question.

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[1] Davidson, *Quart. Journ. Geol. Soc.* Vol. IX, 1853, pl. XV, figs. 3, 4 and 5.

(3) AFGHANISTAN.

The collection of fossils (K. 11·335) made by Mr. Hayden from the road-side at the west foot of the Hajigak Kotal is of Upper Devonian age. The fossils are contained in a dark grey limestone breaking with an irregular fracture and crowded with organic remains, of which the most abundant are a variety of *Spirifer Verneuili* and *Productella subaculeata.* Some specimens are well preserved, but most are poor.

The following is the list of the species :—

Cyathophyllum cf. *hypocrateriforme* Goldf.
Striatopora ? sp.
Spirifer Verneuili var. *Archiaci* Murch.
" sp.

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[1] Davidson, *Mon. Brit. Foss. Brach.* II, p. 97, pl. XIX, figs. 18-21. (*Stroph. productoides* ?)

[2] *Ibid.* pl. XIX, figs. 13-16.

[3] Whidborne, *Mon. Devon. Fauna, Palæont. Soc.* Vol. III, pt. 2, 1897, p. 175, pl. XXI, figs. 6-11.

[4] Davidson, op. cit. Vol. II, p. 231, pl. LIII, fig. 9.

[5] Kayser in Richthofen's 'China', IV, p. 187, pl. XXVIII, figs. 1-5.

Rhynchonella (*Wilsonia*) *cuboides* Sow.
„ („ ?) cf. *Dumonti* Goss.
„ (*Camarotœchia*) cf. *Omaliusi* Goss.
Productella subaculeata (Murch.).
Strophalosia productoides (Murch.).
Stropheodonta interstrialis (Phill.) ?

Notes on some of the Fossils.

SPIRIFER VERNEUILI var. ARCHIACI Murchison.

There are many imperfect examples of a species of *Spirifer* which is indistinguishable from *Sp. Archiaci* (Murchison),[1] a form which is now generally regarded as a variety of *Sp. Verneuili.* Wenjukoff[2] considers *Sp. Archiaci* to be the most ancient member of the group which holds *Sp. Verneuili, Sp. Archiaci, Sp. tenticulum* and *Sp. Brodi,* and that all these others converge to it. It appears that Gosselet's group of *Sp. Verneuili* which he termed *hemicycli*[3] is composed of examples of this type. Davidson[4] comprehended under one specific name, *Sp. disjunctus,* the forms usually referred to as *Sp. Verneuili* and *Sp. Archiaci,* and Martelli[5] has separated off other varieties of this group in studying the Spirifers from Schensi. The resemblance of *Sp. Archiaci* to *Sp.* (*Cyrtia*) *murchisonianus* in external characters has been frequently noticed, and as an example we may mention the figures given by Tschernyschew[6] of *Cyrt. murchisoniana* from the Urals. Scupin[7] has likewise remarked upon the external resemblance of these fossils.

With regard to our specimens from Hajigak Kotal, some completely agree with the shell from Chitral described by Hudleston and

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[1] Murchison, *Bull. Soc. Geol. France,* Ser. 1, Vol. XI, 1840, p. 252, pl. II, figs. 4a-c.

[2] Wenjukoff, Faune Syst. Devon. Nordouest et Centr. Russie, 1886, p. 64.

[3] Gosselet, *Mem. Soc. Geol. Nord.,* IV, No. 1, 1894, p. 25, pl. III, figs. 13, 14; pl IV, figs. 24-28, 30.

[4] Davidson, *Proc. Geol. Soc.* Vol. IX, 1853, p. 354, pl. XV, figs. 1-5.

[5] Martelli, *Boll. Soc. Geol. Ital.* Vol. XXI, 1892, p. 353, t. XIV, figs. 1-3.

[6] Tschernyschew, *Mem. Com. Geol. Russ.* III, No. 3, 1887, p. 77, t. XIII, figs. 4, 5.

[7] Scupin, *Palæont. Abhandl.* Bd. VIII, 3, 1900, p. 5.

McMahon as *Sp. disjunctus*,[1] as I have determined by a comparison with their figured specimens in the British Museum. Just as in the Chitral specimens figured by Hudleston, the outer lateral ribs in the sinus of our specimens meet the edges of the sinus at a very acute angle and do not reach back to the beak, and there is also in some specimens (Hudleston, op. cit. fig. 9) a similar specially deep groove alongside of the fold. Frech[2] has found the Persian examples of *Sp. Verneuili* and *Sp. Archiaci* to be incapable of satisfactory separation. It is not possible to identify satisfactorily any of our specimens with Martelli's varieties from Schensi, but some of ours seem to correspond to the shell which he regards as representing Murchison's type of *Sp. Verneuili*, while others agree better with his varieties *Archiaci* and *subarchiaci*.[3]

RHYNCHONELLA (CAMAROTŒCHIA) cf. OMALIUSI Gosselet. Pl. 8, figs. 2, 2*a*.

There is one fairly well preserved specimen of a species of *Rhynchonella* measuring 15 mm. in width, 11 mm. in height and 14 mm. in length which is probably referable to *Rh. Omaliusi* Gosselet.[4] Our specimen has the typical shape and contour of this form, with 4 plications on the fold of the brachial valve and 7 on each side, while the sinus of the pedicle-valve holds 5 plications of which 3 lie on its floor. The proportions of the shell closely agree with the Belgian species, as do also the ribbing and mode of junction of the valves along the front margin, but the front is not so vertically truncated as Gosselet represents, though this feature often varies within the limits of a species and cannot therefore be considered of great importance.

RHYNCHONELLA (WILSONIA ?) cf. DUMONTI Gosselet. Pl. 8, figs. 1, 1*a*.

The species *Rh. Dumonti* was at first referred by Gosselet[5] to the species *Rh. cuboides* and regarded as merely a variety of it, but subsequently he pointed out in defining it as a distinct species that it differs by being more depressed and narrower and by its plications being finer and more numerous; the beak also is more triangular.

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[1] Hudleston and McMahon, *Geol Magazine*, Dec. 4, Vol IX, p. 54, pl. II, figs. 9-12.

[2] Frech, *Neues Jahrb. f. Miner.*, II, 1895, p. 61.

[3] Martelli. *op. cit.* p. 357, t. XIV, figs. 4-7.

[4] Gosselet, *Ann. Soc. Geol. Nord.*, IV, 1877, p. 314, pl. IV, figs. 6*a-d*; *ibid.* Vol. XIV, 1887, p. 202, pl. II, figs. 1-10.

[5] Gosselet, *op. cit.* IV, p. 315, pl. IV, figs. 7*a-d*.

For these reasons I am inclined to compare certain specimens (six in number) of a *Rhynchonella* from Hajigak Kotal with it rather than to associate them with *Rh. cuboides* of which a typical example occurs in the same bed and locality. The greater number and finer character of the plications is the only point which may be of small value, for in *Rh. cuboides* they vary much. But the latter is typically a more transverse shell with a smaller beak.

The best preserved specimen in our collection measures 20 mm. in length, 17 mm. in width and 13 mm. in thickness. In this shell there are 8 plications on the fold in the brachial valve and 12-13 on each side.

Our shell differs from Gosselet's *Rh. Dumonti* in the frontal and marginal sutures not being so sharply denticulated and in the plications being not quite so numerous; but the general shape of the shell with its more prominent beak and less rounded tongue of the pedicle-valve seems sufficient to separate it from *Rh. cuboides.*

PRODUCTELLA SUBACULEATA Murchison.

This[1] is one of the most abundant fossils at this locality, and it is a very widely distributed species in Asia as well as in Europe. The specimens are all of small size, none exceeding about 15 mm. in length.

STROPHALOSIA PRODUCTOIDES Murchison.

A few typical examples of this species occur in the collection.

CYATHOPHYLLUM cf. HYPOCRATERIFORME Goldfuss.

There is one portion of a large corallum of a compound *Cyathophyllum* showing about thirty corallites. From its general characters it may be compared with *C. hypocrateriforme* Goldfuss.[2]

(4) HIMALAYAS.

(*a*) Byans.

The small collection of fossils (K. 6·620) made by Mr. F. H. Smith in 1889 from a locality "1 mile north of Tera Gadh Camp, Byans" was believed to be of Lower Carboniferous age. But the fossils, so far as they are determinable, indicate a Middle Devonian age, and the following is a list of the species. The rock in which they occur is a dark compact limestone.

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[1] Murchison, *Bull. Soc. Geol. France* Ser. 1, Vol. XI, 1840, p. 255, pl. II, figs. 9 *a*, *b*, *c*.

[2] Frech, *Palæont. Abhandl.* Bd. III, Heft 3, 1886, p. 78, t. III, figs. 15-18.

Atrypa reticularis var. *desquamata* Sow.
„ *aspera* (Schloth).
Pentamerus cf. *sublinguifer* Maurer.
Camarophoria cf. *Phillipsi* (Dav.).
Rhynchonella (*Wilsonia*) cf. *omega* Whidb.
Orthis aff. *bistriata* Tschern.
Pterinopecten or *Aviculopecten* ? sp.
Orthoceras sp.
Favosites cf. *basaltica* Goldf.

Notes on some of the Fossils.

FAVOSITES cf. BASALTICA Goldfuss.

There is one sublobate corallum of a species of *Favosites* split down the middle, which shows the corallites in longitudinal section. They are hexagonal, of subequal size, averaging 1·8 to 2 mm. in diameter, with the walls transversely ridged and striated and the angles interlocking in a series of blunt prominences as in a new species from the Silurian of Spiti. The pores are uniserial, equidistant, and rather large, and form a single row down the middle of each face. The internal characters are not seen. It appears to be comparable to *Fav. basaltica* Goldfuss.[1]

ATRYPA RETICULARIS var. DESQUAMATA Sow.

There are five small specimens averaging about 17 mm. in length which seem to be identical with the small variety of *Atrypa reticularis* occurring at Padaukpin which I have referred with some hesitation to *A. desquamata* Sowerby.[2]

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[1] Goldfuss, *Petref. Germ.* p. 78, t. XXVI, figs. 4 *c*, 4 *d*.

[2] Reed, Devonian Faunas, Northern Shan States, *Palæont. Ind.* n. s. Vol. II, Mem. No. 5, 1908, p. 98, pl. XV, figs. 8, 9, 9*a*.

PENTAMERUS cf. SUBLINGUIFER Maurer.

One complete but distorted globose smooth brachiopod closely resembles the specimens attributed by Whidborne[1] to Maurer's *Pentamerus sublinguifer.*[2] The almost equal beaks, shallow sinus in the pedicle-valve with tongue-like projection and indistinct or obsolete fold on the opposite valve are features which are well seen.

RHYCHONELLA (UNCINULUS) cf. OMEGA Whidborne.

One specimen of a *Rhynchonella* is probably identical with Whidborne's *Wilsonia omega*[3] from the Middle Devonian. Though somewhat crushed it appears to have possessed the characteristic contour and ribbing of this globose species, as a comparison with the type-specimen in the Sedgwick Museum proves. This species seems to belong to that group of American forms containing *Uncinulus mutabilis* Hall, and *Uncinulus nobilis* Hall, from the Lower Helderberg.[4]

CAMAROPHORIA cf. PHILLIPSI (Davidson).

There are four imperfect and distorted specimens which resemble *Camarophoria Phillipsi* (Davidson)[5] more closely than any other rhynchonelloid. This species varies much in external appearance, as Whidborne[6] has remarked.

ORTHIS aff. BISTRIATA Tschernyschew. Pl. 8, figs. 9, 10.

Tschernyschew[7] has described and figured a new species of *Orthis* from the Middle Devonian of the Urals which bears a great resemblance in the style of its ornamentation and general characters to certain small examples of this genus from Tera Gadh in Mr. Smith's collection.

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[1] Whidborne, *op. cit.* p. 123, pl. XIV, figs. 6-8.

[2] Maurer, *Abhandl. Grossh. Hess. Geol. Landes*, Vol. 1, pt. 2, p. 218, pl. IX, figs. 7-10.

[3] Whidborne, *Mon. Dev. Fauna*, Vol. II, pt. 3, 1893, p. 135, pl. XV, figs. 5, 5*a*, *b*.

[4] Hall and Clarke, *Palæont. N. Y.*, Vol. VIII, Brach. II, p. 199, pl. LVIII, figs. 22-26.

[5] Davidson, *Brit. Foss. Brach.* V, pt. 1, 1882, p. 43, pl. II, fig. 14.

[6] Whidborne, *op. cit.*, p. 141, pl. XVI, figs. 1, 2.

[7] Tschernyschew, *Mem. Com. Geol. St. Petersburg*, Vol. III, No. 3, 1887, p. 179, t. XII, figs. 8, 9.

Our shells have a subcircular or transversely elliptical shape, are weakly biconvex, but have the pedicle-valve slightly more convex than the brachial with the beak rising a little above the hinge-line and incurved. The hinge-line is straight and equal to one-half to three-fourths the width of the shell. The surface is ornamented with from 50 to 80 fine regular equidistant rounded thread-like ribs of equal size and continuous from the beak to the margin with a few rather shorter ones of equal size intercalated. The rather wide interspaces between these ribs are occupied by 2-3 much finer thread-like lines. The shell substance is minutely punctate.

The number of ribs in our specimens is much greater than in *O. bistriata* according to Tschernyschew, and probably it is a distinct though allied species. The material is, however, too poor for a satisfactory specific diagnosis. Our shells measure 8—10 mm. only in length.

ORTHOCERAS sp.

A fragment of a species of *Orthoceras*, crushed and flattened, is too poorly preserved to allow of its specific identification. It measures about 40 mm. in length, and the rate of tapering seems to have been slow. It is ornamented by regular equidistant and equal narrow concentric rings, apparently horizontal and not undulated; they are closely placed, 9 or 10 occurring in a distance of 5 mm. The position of the siphuncle is not determinable, and the true affinities of this form are uncertain.

Note.

There are two specimens collected by Griesbach from perhaps the same locality and horizon as those in Mr. F. H. Smith's collection, but they are in a poor state of preservation. They are labelled, nos. G $\frac{367}{60}$, G $\frac{367}{61}$, "Lower Carboniferous, Upper Tera Gadh, Kali river valley." The rock is a black limestone with shaly carbonaceous films and patches. One specimen (G $\frac{367}{61}$) exhibits a fragment of the reverse face of the zoarium of a species of *Fenestella*. The branches are slender, fairly straight and sub-parallel; the dissepiments are less thick than the branches and placed at fairly regular distancesa part. The fenestrules are quadrangular, of subequal size and about twice as long as wide or rather longer, and the branches are usually less than one-third the width of the fenestrules. In weathered portions of the specimen it is seen that there are 5-6 zoœcia to each fenestrule.

There are also on the same piece of rock numerous portions of a ramose Favositid coral, with cylindrical branches, averaging 5 mm. in diameter and consisting of polygonal corallites of subequal size, diverging from the axial line and meeting the surface obliquely or at right angles; their walls are not thickened and the coral is much like *Favosites cervicornis* (Blainv.) so far as can be determined. Griesbach's other specimen (G $\frac{367}{60}$) contains a fragment of the same organism.

(*b*) **Kanaur.**

A small collection of fossils (K. 6·597) was made by Messrs. Hayden and Krafft in 1901 at a locality on the Yulang River, Kanaur (31° 55′: 78° 36′), and the beds were doubtfully referred to the Devonian. The rock is a dark grey fissile limestone containing an abundance of flattened and crushed shells of a large brachiopod referable to the genus *Orthothetes.* This fossil occurs abundantly in layers, and with the exception of about half a dozen specimens of other genera is practically the only organism represented. There are a few blocks of a black non-fissile and massive limestone from the same locality containing examples of the Stromatoporoid described below; probably these are from a slightly different stratum, but of this I have no information. A solitary specimen of a simple turbinate cyathophylloid coral occurs in the same rock; its generic position is quite uncertain.

This small fauna suggests an Upper Middle Devonian or Upper Devonian age.

The following is a list of the fossils :—

Atrypa aspera Schl.
Orthothetes aff. *crenistria* Phill.
Productella or *Strophalosia* sp.
Idiostroma yulangensis sp. nov.
Cyathophylloid coral.
Crinoid stems.

Notes on some of the Fossils.

ORTHOTHETES aff. CRENISTRIA Phillips.

None of the specimens of this abundant shell are well preserved and most of them are fragmentary. The species has the typical shape and relative convexity of *O. umbraculum*, with the contour of the shell and shape of the cardinal angles varying as usual according to the age. The hinge-area on the pedicle-valve has the typical characters, and the cardinal process of the brachial valve appears to have the usual bilobed flattened shape. With regard to the muscle-scars, which are usually badly preserved in our specimens, there appear to be no constant or important differences, so far as can be seen. It is only with regard to the ornamentation of the surface that certain distinctive features are noticeable. The ribs are rather finer and more numerous than in *O. umbraculum*; the interspaces are generally rather wider, and there are no crenulations or granulations present on the ribs as a rule. The mode of increase by intercalation seems indistinguishable, and the ribs are likewise of a uniform or subequal strength near the margin, except in the case of the shortest ones. In the general smoothness of the ribs we see a resemblance to *O. devonicus* D'Orb.[1] and *O. hipponyx* Schnur, as defined by Oehlert[2]; many examples of *O. crenistria* Phill.[3] approach this Kanaur shell very closely, and the specimens from the Devonian of Siberia attributed by Stuckenberg[4] to this species may be especially noticed. In a few cases we can see that there are fine concentric lines crossing the ribs and interspaces of our shells, but they do not attain the coarseness found in typical adult specimens of *O. umbraculum*, though some of the Kanaur shells reach the large size of 40 to 50 mm. in width.

The American species *O. chemungensis* Conr.[5] appears to be somewhat closely allied.

IDIOSTROMA YULANGENSIS sp. nov. Pl. 8, figs. 11, 11*a*, *b*, 12.

Diagnosis.—Cœnosteum fasciculate, composed of sub-parallel subcylindrical stems from 4 to 12 mm. in diameter, branching and inosculating irregularly. Cœnosteal tissue reticulate, built up of definite concentric layers. Radial pillars rarely individualised, generally not continuous across latilaminæ (except near periphery), usually short and interrupted. Interlaminar spaces fairly regular and continuous near periphery, but resolved into irregular spongiose tissue towards centre of stem. No definite axial canal. Zooidal tubes vermiculate, small, of nearly uniform size, rarely with traces of tabulae. Skeletal fibre dense, minutely porous. *Caunopora*-tubes present.

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[1] Barrois, *Mem. Soc. Geol. Nord*, Vol. III, 1889, p. 69.

[2] Oehlert, *Bull. Soc. Geol. France*, Ser. 3, Vol. XXIV, 1896, p. 856, pl. XXVII, figs. 9-11.

[3] Davidson, *Mon. Brit. Foss. Brach.*, Vol. II, p. 124, pl. XXVI.

[4] Stuckenberg, *Mem. Acad. Imper. Sc. St. Petersburg*, Ser. 7, Vol. XXXIV, No. 1, 1886, p. 6, t. III, figs. 1-5.

[5] Hall and Clarke, *Palæont. N. Y.*, Vol. VIII, Brach. I, 1892, p. 255, pls. X and XIA.

Remarks.—The mode of growth of this stromatoporoid is similar to that of *Idiostroma oculatum* Nich.,[1] and thin sections show that internally the structure also bears a close resemblance. But there seems to be no definite axial tube, and the irregularly radiating or vermiculate zooidal tubes are relatively smaller and less numerous, while the interlaminar spaces near the periphery are more continuous and the radial pillars less developed. The typical minute structure of the genus is, however, unmistakeable.

(*c*) Upper Spiti.

A small series of specimens was collected in 1901 by Messrs. Hayden and Krafft from a locality "between Losar and Trakse, Upper Spiti" (32° 27′: 77° 47′). Some of the rock specimens (K. 6·597) are identical in character with the fossiliferous Devonian limestone from Kanaur, but are not so much crushed; they contain examples of the same *Orthothetes*, but the shells usually show more distinctly the crenulations on the ribs and indeed more closely approach *O. umbraculum* in character. The other rock-specimens (K. 6·597) from this locality consist of a crushed whitish semicrystalline limestone crowded with specimens of a large *Orthothetes* apparently identical with the Kanaur form. It is doubtful if any other species or genus is represented in this poor and fragmentary material.

GENERAL REMARKS ON THE ABOVE MENTIONED COLLECTIONS.

The evidence of the above described Devonian fossils fully bears out the conclusions at which I have previously arrived[2] with regard to the geographical movements and distribution of the faunas of this period in Asia. The south European or Bohemian element is found to be present in the lower beds, but is overwhelmed or exterminated by the great transgression of the north European types in Middle and Upper Devonian times. The material which we have at present available is too scanty and poor to enable us to determine if any American elements penetrated into the Himalayan region or further west at this period. But so far as we know the facies is entirely European.

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[1] Nicholson, *Mon. Brit. Stromatoporoids,* (*Palæont. Soc.*) 1892, p. 225, pl. XXIX, figs. 8-11, woodcuts 32 and 38.

[2] Reed, Pre-carboniferous Life-Provinces, *Records, Geol. Surv. India,* Vol. XL, . 1, 1910, pp. 28-31 and references.

EXPLANATION OF PLATES.

PLATE 7.

FIG. 1. *Proetus chitralensis* sp. nov. Internal cast of pygidium. × 1½. From the neighbourhood of the Barogbil Pass, Chitral. (Approx. Lat. 37°; long. 73° 20′.) Coll. Lieut. I. H. Grant.

" 2. *Proetus chitralensis* sp. nov. Imperfect pygidium with shell preserved. × 2. Same locality and collector.

" 3. *Proetus chitralensis* sp. nov. Internal cast of imperfect pygidium. × 1½. Same locality and collector.

" 4. *Proetus chitralensis* sp. nov. Axis of pygidium with shell preserved. × 2½. Same locality and collector.

" 5. *Proetus chitralensis* sp. nov. Imperfect free cheek with shell preserved. × 2. Same locality and collector.

" 6. *Proetus chitralensis* sp. nov. Inner surface of complete free cheek. × 2. Same locality and collector.

" 7. *Pterinea* sp. Right valve. × 2½. Same locality and collector.

" 8. *Spirifer* cf. *robustus* Barrande. Imperfect pedicle-valve. Nat. size. Same locality and collector.

" 8*a* *Spirifer* cf. *robustus* Barrande. Posterior view of same specimen. Nat size.

" 9. *Spirifer* aff. *primævus* Stein. Pedicle-valve. Nat. size. Same locality and collector.

" 10. *Pentamerus* (*Sieberella*) *Sieberi* Von Buch. Brachial valve. Nat. size. Same locality and collector.

" 11. *Chonetes* aff. *embryo* Barrande. Pedicle-valve. × 2½. Same locality and collector.

" 12. *Productella* ? sp. Pedicle-valve. × 1½. Same locality and collector.

PLATE 8.

FIG. 1. *Rhynchonella* (*Hypothyris*) cf. *Dumonti* Gosselet. × 2. From roadside at west foot of Hajigak Kotal. Coll. H. H. Hayden.

" 1*a*. *Rhynchonella* (*Hypothyris*) cf. *Dumonti* Gosselet. Side view of same specimen × 2.

" 2. *Rhynchonella* (*Camarotœchia*) cf. *Omaliusi*, Gosselet. × 2. Same locality and collector.

FIG. 2*a*. ***Rhynchonella* (*Camarotœchia*)** cf. ***Omaliusi*** **Gosselet.** Anterior view of same specimen. × 2.

„ 3. *Spirifer Verneuili* Murchison, var. nov. *persica*. Pedicle-valve. × 2. From hills S. of Raband, Mashhad district, Khorasan. Coll. Griesbach.

„ 4. *Spirifer Verneuili* Murchison, var. nov. *persica*. Imperfect brachial valve of young shell. × 2. From hills S. E. of same locality. Coll. Griesbach.

„ 5. *Spirifer Verneuili* Murchison, var. nov. *persica*. Imperfect pedicle-valve. × 2. From hills S. of same locality. Coll. Griesbach.

„ 6. *Strophalosia* ? sp. Brachial valve. × 2½. From hills S. of same locality. Coll. Griesbach.

„ 7. *Stropheodonta interstrialis* (Phillips). Brachial valve. × 2½. From hills S. E. of same locality. Coll. Griesbach.

„ 8. *Stropheodonta interstrialis* (Phillips). Portion of impression of inner surface of shell. × 6. From hills S. of same locality. Coll. Griesbach.

„ 9. *Orthis* aff. *bistriata* Tschernyschew. Pedicle-valve. × 2½. From 1 mile N. of Tera Gadh camp, Byans. Coll. F. H. Smith.

„ 10. *Orthis* aff. *bistriata* Tschernyschew. Pedicle-valve showing cast of muscles. × 2½. Same locality and collector.

„ 11. *Idiostroma yulangensis* sp. nov. Section of part of cœnosteum. Nat. size. From Yulang River, Kanaur, (31° 55′ : 78° 36′) Coll. H. H. Hayden.

„ 11*a*. *Idiostroma yulangensis* sp. nov. Transverse section of one branch of same slice. × 6.

„ 11*b*. *Idiostroma yulangensis* sp. nov. Longitudinal section of portion of one branch of same slice. × 6.

„ 12. *Idiostroma yulangensis* sp. nov. Transverse section of part of a branch of another slice from same specimen. × 6.

SECTIONS IN THE PIR PANJAL RANGE AND SIND VALLEY, KASHMIR. BY C. S. MIDDLEMISS, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 9 to 12.)

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I.—SECTIONS IN THE PIR PANJAL.

Introduction.

Revision necessary.

DURING the latter part of the summer of 1910, a portion of the Pir Panjal range was explored by me, with results so divergent from those obtained by R. Lydekker during his general survey of the area (see *Mem., Geol. Surv. of India,* Vol. XXII, 1882) as to call for a fresh description.[1]

[1] Both the words "Pir" and "Panjal" signify a mountain peak or range, the former being the Dogri and the latter the Kashmiri word. To speak therefore of the Pir Panjal range is three-fold tautology. Partially to avoid this, I have used the word " range " once, for explanatory purposes; afterwards, I shall be content to speak of the " Pir Panjal ".

A glance at Lydekker's map accompanying his memoir will show that, lying parallel to a gneissose and metamorphic central range, the flanks on either side, over wide distances, were depicted as Panjal slates and Panjal Trap, of Silurian age or older. But, in consequence of the changes found necessary by me during 1909 in working out the stratigraphical relations of the so-called Panjal System of Lydekker, as exhibited in the Lidar valley, etc. (see *Rec. Geol. Surv. of India,* Vol. XL., pt. 3) it will be obvious that there must be a corresponding change or readjustment here also among strata thus denominated: for the Panjal trap we now know must no longer be considered as of Silurian age or older, but as Upper Carboniferous at the earliest, whilst the rest of the Panjal system of conglomerates and slates must partially undergo a similar redistribution in the time-scale—certain large portions of them (my agglomeratic slate) accompanying the traps, whilst others remain with the Silurian.

If the above readjustment, as a corollary to the splitting up of the Panjal system, were all the changes involved in the area now before us, it would hardly be necessary to describe afresh any detailed sections in the range. My survey has, however, brought to light the necessity for other considerable alterations in the cartography that are additional to, and quite independent of, the above internal changes in the Panjal system.

Lest it should be thought that in putting forward the results of this later work of mine with its extensive revision, I am taking undue liberties with Lydekker's descriptions, I would recall to mind the following words of Lydekker himself (p. 2 of his memoir):—"It must not, however, be considered that the present memoir has any pretence to be a complete and detailed account of the geology of the region of which it treats. It must, on the other hand, be regarded rather in the light of a foundation or stepping stone from whence future more detailed work may take rise".

Geographical outline.

The Pir Panjal is a familiar and beautiful sight to all visitors to the valley of Kashmir. On the journey up from the plains it must be traversed by means of the Baramullah gorge, or by one of the less accessible passes; whilst, from almost every part of Kashmir proper, its long, low dip slopes and culminating jagged and snow-covered peaks may be seen bounding the valley to the south-west.

It rises to a height of over 15,000 feet, and though there are only very insignificant remnants of glaciers now left occupying the "cwms" and higher valley heads, such has not always been the case, as is testified to by the great thickness and extent of old moraine material lying on most of its north-east flanks, and almost burying the solid geology out of sight.

Structurally it is in the main an orthoclinal range, and much of it is of the type known to mountaineers as " writing-desk " pattern, having gently or steeply inclined dip-slopes to the north-east, and more precipitous scarps to the south-west. It thus differs materially from the ranges further north, being less complex and of a much younger type as regards its folding and sculpture than they—in which respect it approaches more nearly to the Sub-Himalayan type of hills which lie at its south-west foot.

Its structural continuation to the north-west across the Baramullah gorge is known as the Kajnag range, whilst to the south-east it is continued more or less obscurely for a long way across the Chenab R. to link up with either the Dhauladhar range or the " great Himalayan range " of Burrard[1] according to the connotation attached to the word mountain range.

It is heavily wooded on the north-east face with fir, spruce, pine and birch up to about the 12,000 feet level, with here and there open grazing grounds, which during the summer months are dotted with the more or less permanent encampments of shepherds and herdsmen. The charming hill-station of Gulmarg lies at a height of 8,000 feet on its meadowy slopes. Above 12,000 feet the higher, barer surfaces and clusters of peaks are frequently snow-covered, whilst in the winter, snow descends much lower and well into the forest zone.

Lydekker's description.

Lydekker (as will be seen by his map and pp. 211-217 and 290-292 of his memoir) depicted and described the line of central peaks of the range as being predominantly composed of crystalline and metamorphic rocks, namely, gneiss or gneissose granite and metamorphic schists, the latter being considered to be usually of a geological horizon between that of his Panjal system (Silurian and ? Cambrian) and the Archæan gneissose rocks—though they might also include a portion of the Panjals. On each side of the central axis the higher flanks were assigned by Lydekker to the Panjal system (or to the unmetamorphosed part of it) consisting of slates and similar rocks; whilst a border of Panjal Trap was shown along the lower north-east margin where the Panjal system comes into contact with, and is overlaid by, the Post-Pliocene Karewa deposits. Another similar border of Panjal Trap was shown on the south-west or Jamu side of the range, with the addition of a narrow outcrop of Kuling (Permo-Carboniferous, etc.) abutting against the main-boundary fault, which fault introduces the Murree beds of the younger Tertiary Sub-Himalayan zone. The arrangement as seen in plan (according to Lydekker) was in fact as follows :—

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[1] *A sketch of the Geography and Geology of the Himalaya Mountains and Tibet.* By S. G. Burrard and H. H. Hayden, Calcutta, 1907.

N. E.
Karewa, Post-Pliocene.
Panjal Traps.
Panjal Slates.
Gneissose and metamorphic.
Panjal Slates.
Panjal Traps.
Kuling (Permo-Carboniferous)
Murree Beds.
S. W.

Main points of difference.

It will now be well, before proceeding to the description of individual sections and routes, to outline briefly the main points in which my mapping differs from the above.

(1) The central line of culminating peaks and watershed, where seen by me, have been found to be not gneissic rocks or ancient metamorphic rocks, but either amygdaloidal and compact varieties of the Panjal trap (exactly reproducing the characteristics in the field of those described not only by me but by Lydekker himself on the north side of the Kashmir valley) or agglomeratic slate, or even the younger Gondwana series. Neither at the Golabgarh Pass, Tatakuti and the Chota Gali Pass, the heights above Toshmaidan nor on the main range above Gulmarg, nor I may add at any of the intermediate places between the last three, have I seen a trace of gneiss or granite or any similar rock either *in situ* or as boulders in the moraine debris that lavishly strews the whole of the north-east slopes of the Pir Panjal. It is, however, well known in the Kajnag continuation of the range, and I have recorded it at the southwest foot of the

Pir Panjal below the Golabgarh valley. Slightly metamorphosed slates and quartz-schists also occur on Apharwat above Gulmarg, but they are altered Gondwanas (see also p. 134).

(2) I have found no Panjal slates (using the word in its Lydekker sense of Silurian and older) lying next to and N. E. of the central ridge as marked by Lydekker.

(3) For some distance in the neighbourhood of Fras Nag the border of older rocks coming next the Karewas, I have found to be also not Panjal Trap as marked by Lydekker, although the latter *as boulders* fills all the stream beds which descend from the old moraines, on that side.

(4) I have found a large development of Lower Gondwanas, Permo-Carboniferous limestones and shales (Lydekker's Kulings) and Upper Trias limestones (Lydekker's Supra-Kulings) along the north-east slopes; none of which have been marked by Lydekker.

These widely different results obtained by my survey, it will be seen, are not a mere adaptation of the splitting up of the Panjals to this part of Kashmir, but are largely connected with my more detailed investigation of certain parts of the Pir Panjal itself, parts which apparently were unvisited or only cursorily visited by my predecessor.

Routes.

Of the four routes evidently used by Lydekker, namely, the Baramullah gorge, Nilakanta pass, the Pir Panjal pass and the Banihal pass, I have no acquaintance with the two latter, and so do not for a moment maintain that Lydekker was in error in matters of simple fact so far as they are concerned. But I hope to establish from the detailed sections which follow along the Nilnag-Tatakuti and Gulmarg-Apharwat lines of route, as well as by reference to the Golabgarh route traversed by me in 1908,[1] that these parts bear the very different geological stamp outlined above, and that the scheme propounded by Lydekker can by no means therefore be applied to the whole length of the range, as he has so applied it, whatever be the case as regards one or two special sections. The relative positions of these routes will be understood from the sketch map (Plate 11).

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[1] *Rec. Geol. Surv. of India,* Vol. XXXVII, pt. 4, 1909.

Nilnag-Tatakuti Section.

Karewas.

An outline of the structure along this line of section is shown in Plate 12, fig. 1. Leaving Srinagar (the capital of Kashmir), whose elevation is 5,276 feet, by the silk factory road and proceeding in a S.S.W. direction, the first strata that are met with when once the long alluvial stretch of the flat valley is passed, are the very gently inclined Post-Pliocene Karewa deposits which sheet in the north-east slopes of the range at this point. These have been well described by Lydekker and others,[1] so that the few remarks that I shall make about them will be merely as a basis for recording a find of well-preserved fossil leaves that I was fortunate in coming across.

Gently inclined position.

Gradually, as the gradient increases, the Karewa plateaux lift their summits above the most recent alluvium of the intervening stream beds, all of which descend from the direction of the Pir Panjal. Then, near Nagam, the now sensible dip slope of the rather older Karewas unites the previously isolated plateaux into continuous gently upward sloping ridges with a nearly uniform crest. The fine, soft sands, clays and loams, of a bright ochre tint, that compose these slopes has been freely cut into by the streams, making here and there fresh-scarped cliffs, long steady slopes, or gently graded staircases of landslips (or rather subsidences) of the loosely coherent rock. One of these, three days old, was observed by me on my journey up, at a position a little below the village of Nilnag. The soil, subsoil, and scarcely consolidated sand and loam beds of the Karewas had sagged, slipped, and finally flowed forward like a glacier or mud-flow, exhibiting typical crevasses and other features characteristic of a moving viscid body. The pretty little lake of Nilnag, enclosed by pine-clad hills, owes its formation to ancient landslips of this kind.

Fossil shells.

At Gojipatri, near the lake, the prominent line of ochre-tinted cliffs shows that the dip of the strata has now attained an angle of about 10°. Here were collected a few very imperfect shells and leaves. The latter were unfit for keeping, the former included several examples of *Planorbis* and some unrecognisable fragments.[1]

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[1] See Godwin-Austen, *Quart. Journ. Geol. Soc.*, Vol. XV, p. 221, and Vol. XX, p. 383.

Monoclinal fold.

A few miles south-west of Gojipatri the ascending slope of the much dissected block of strata forming the Eosu and Nilnag mass, with a maximum elevation of 8,271 feet, (Eosu Station) is interrupted by a sharp but temporary drop exhibiting a very small but distinct monoclinal fold in soft loam, sands, brown sandstone and conglomerate beds with occasional *kankar*. The dips at this point are as much as 40° S. W., that is to say, in the opposite direction to the prevalent dip of the formation. This quickly gives way as the slope recovers along the higher reaches of the Sangsofed river to the normal north-east dip as before (see Section Plate 12, fig. 1).

The whole of the country here lies at so low an angle and is so softly rounded that if it were at a lower elevation and were clothed with *Sal* or other more tropical forest instead of pine, one could not distinguish it from much of the Sub-Himalayan zone, as for instance that of the Dehra Dun or Patli Dun. The large tract marked on the Atlas of India sheet as " long low slope covered with dense pine forest " has uniformly this character.

Fras Nag and Ludar Marg.

From Eosu Marg upwards all the stream beds are choked with large rounded and sub-angular blocks of Panjal Trap, which have been derived from the moraines higher up; whilst soil and forest are so thick on the slopes that Karewas are only exposed here and there, until finally near Fras Nag and Ludar Marg they cease entirely at their highest found exposure (between 11,000 and 12,000 feet) and near the present forest limit.

Leaf bed in Karewas.

At the latter place, mixed up with the outcrops of Upper Trias limestone, there occur patches of Karewas consisting of finer grained and more compact sandy shales, of a pale drab or French grey colour. They are exposed in two little stream beds near the present *Gujar* (herdsmen) encampment of Ludar Marg (lat. 33° 48′, long. 74° 39′). The dip is of the usual slightly inclined character, and the beds were found to contain a flora of well-preserved leaves. In the damp state in which they were extracted the leaves had much the same toughness as a photographic film, but on exposure to the air in a dry climate they crumbled away. Fortunately, by wrapping up the specimens as they were gathered, in many folds of paper and packing them up on the spot, they were eventually able successfully to withstand the journey to Calcutta There, by painting them, at Mr. Blyth's suggestion, with gelatine first and Canada balsam varnish afterwards, I was able to preserve a large number showing all the delicate venation, serrated edges, and in one or two instances even the deep red tints of the original fallen leaves.

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[1] See also Godwin-Austen, *Quart. Journ. Geol. Soc.*, Vol. XX, 1864, p. 383, where land and fresh-water shells together with plants and minute fish-scales are recorded from this neighbourhood.

By far the most numerous genus represented is an oak, near to *Quercus glauca,* Thunb. There are a few examples of *Alnus* and *Cinnamonum* (one of the latter being very like *C. Tamala,* F. Nees) together with one leaf of box, *Buxus sempervirens,* Linn. and one leaf very like *Jasminum.* A few other indeterminate common types of leaves are represented in the collection. All the above are living genera, and probably indicate a prevailing oak forest, such as now is found at about 4,000 to 5,000 feet, together with a few other trees interspersed with them, such as the alder and *Cinnamonum.* The box leaf may have been washed down from greater heights.

Comparing this with the present prevailing forest flora, we find considerable differences. The latter, as already stated, consists of fir, pine and spruce, with birch at the higher levels. *Alnus nitida,* Endl. is common now at 7,000 feet by the side of streams, but there is neither oak nor box in the Kashmir valley or on its mountain sides at the present day—(W. R. Lawrence " The valley of Kashmir ", p. 79)—although the former is plentiful enough in the near neighbourhood of the Murree Hills.

I am indebted to Mr. I. H. Burkill, Reporter on Economic Products to the Government of India, for his kind assistance in determining the leaves.

Thickness, etc.

This glimpse of the Karewa system tells us little about the absolute thickness attained by it. Dip slopes of this character are always difficult to estimate. Many hundreds of feet are certainly present, and it is probable that 1,400 feet, as recorded by Godwin-Austen (*loc. cit.*) is not over the mark. In other ways, however, the deposit is very suggestive. The nature of the flora, and inclined position of the strata, together with the small monoclinal pucker at Eosu station point to a relatively late continuance of the upheaval of the Pir Panjal by lateral thrust along lines of much older movement.

Upper Trias limestone.

Reverting from this description of the Karewa leaf beds to the general line of section, we must note the first appearance of rocks older than the Karewas, namely, the Upper Trias limestone already alluded to, which, with a dip of 60° N.E., is present between Ludar Marg and Fras Nag, being well exposed at the source of the springs to which the name Fras Nag is applied. Although the exposures are isolated and have yielded no fossils, the resemblance of the rock to the similar, generally barren limestone of enormous thickness that comes above the richly fossiliferous Muschelkalk, Lower Trias and Permo-Carboniferous in the sections on the opposite side of the Kashmir valley is so strong that one may confidently make the correlation.

Old moraines.

Beyond and above Ludar Marg in the direction of the central peaks, a marked change in the face of the country sets in, exposures of solid strata are still extremely rare, but this is not on account of the dense forest as hitherto (which has ceased) but because of the old stranded moraines and morainic material which now in turn effectually hides the older rock series. This ancient glacial deposit is present in a condition of wonderful preservation. Although in its lower part it fades imperceptibly into the train of boulders occupying the stream beds, there comes a position, varying between the 10,000 and 11,000 feet levels, where, constituted as it is of partly re-made and resorted moraine, it covers the north-east slopes of the range in a continuous belt of intermingling debris streams and fans. At still higher levels, between 11,000 and 12,000 feet, the same material, but in its more original unsorted state, is found debouching from the numerous higher valleys in pairs of beautifully regular lateral moraines 500 feet thick. And yet these points of emergence of the stranded moraines are now several miles from, and 2,000 feet below, the present-day belt of live ice and active moraines! The sole contrast between the old and the recent moraines is that the former are uniformly grassed over, and even partly forest-covered with scanty birch trees and dense clumps of stunted juniper. In all other respects these vast superficial ice-formed accumulations appear to have hardly changed their original contours at all since first made (see Plate 9).

To the eye the resulting country has the appearance of extensive undulating downs, diversified by stony torrents. In travelling over it one passes from long stretches of the softest grass, broken only by a few swampy patches, to what often prove to be quite formidable obstacles, namely, trains of closely jammed, enormous, angular blocks composed exclusively of Panjal Trap. These may either fill the smaller depressions of the surface or they may sweep in long curves along or across the undulations; thus indicating that they enter directly into the composition of the moraines as streaky patches of coarser material. They are difficult and always tedious to cross on foot, and are an absolute check to baggage animals, which not seldom must wander long distances by their banks before they can find a passage.

Rock series hidden.

Thus are lost to view all the rock series, including most of the enormously thick Upper Trias and any possible representatives of the Muschelkalk and Lower Trias, that might by chance have been present, until, on reaching a point in the Sangsofed river, 4 miles north-east of Tatakuti, the higher ridges and spurs begin to emerge through the glacial deposits, and continuous solid rock is once more found in a fine U-shaped valley cut through Panjal Trap, Gondwanas and Permo-Carboniferous.

Section 4 miles north-west of Tatakuti.

The dip in the cliffs on the south-east side of the U-shaped valley is, however, in agreement with that of the Upper Trias of Ludar Marg, and there is no reason to doubt that the intervening strata though hidden are really continuously present. The cliffs on the north-west side of the valley show local inversion, the sequence and strike remaining the same.

The following is a description of the cliff section now before us:—

(1) Panjal Trap, in all its characteristic forms as a bedded mass reaches a long way up the valley and is of the usual enormous thickness. It is here and there penetrated by white quartz veins, some prominent blocks of which lying on the gravelly river bed a little above the section give the name of Sangsofed (white stone) to the locality and river.

(2) Above this and normally dipping down stream, *i.e.* north-east at 65°, come about 200 feet of eminently characteristic Lower Gondwana carbonaceous shales or slates and dark quartzitic grits, which have been cut back by weathering as compared with the trap, causing a gap in the cliffs on each side of the river. In the cliffs on the right (south-east) bank I was gratified after a prolonged search, by finding a somewhat imperfect, but quite sufficiently recognisable, Lower Gond-

wana flora consisting of fronds of *Glossopteris*, *Gangamopteris*, *Psygmophyllum ? Alethopteris ?* and other plant fragments in a rather more compact layer among the carbonaceous shale or slate series.

(3) This is directly succeeded by a similar thickness of pale grey limestone and shales which introduce the base of the marine Permo-carboniferous The limestone beds contain *Productus lineatus*, Waag., *P. scabriculus*, Mart., *Spirifer fasciger*, Keys. and others, *P. lineatus* being very numerous. All are fairly well preserved. Among the interbedded shales occur a few examples of *Protoretepora ampla*, Lonsd. and *Thamniscus* sp.

(4) The shales gradually become more pronounced, and for about 200 feet are full of the characteristic *Protoretepora ampla* together with *Thamniscus* and several specimens of *Lyttonia*.

(5) The section then becomes almost barren of fossils, and there is an apparent absence of the richly fossiliferous layers with *Spirifer Rajah*, Salt. and *Marginifera Himalayensis*, Dien. that are so remarkable on the other side of the Kashmir valley at about this horizon.[1] Sandy shales with a few hard sandstone bands continue for about 1,000 feet more, but there are only insignificant fossil-bearing beds, such as (7) 1-9-10 with *Pecten* sp. and (8) 1-9-10 with *Pseudomonotis*, the latter being a thin-bedded pale shale.

Horizons (3) and (4) of the above category are clearly Permo-Carboniferous or Zéwan, as is proved by the presence of *Spirifer fasciger*, *Protoretepora ampla*, *Lyttonia* and the *Productidæ*, and by the general lithology and sequence of the series as a whole. The uppermost part of (5) from the presence of *Pseudomonotis* may be quite near the base of the Lower Trias.

No recognisable Lower or Middle Trias, with cephalopods, have, however, been found in this section or in any others in the range further north-west, and the same was the case in the Golabgarh Pass section.

After bed (5) the exposures are entirely concealed by the upper end of the twin lateral moraines.

In describing the above section in the Permo-Carboniferous I have combined observations from both sides of the river bed, according to their individual productiveness and accessibility.

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[1] *Rec. Geol. Surv. of India*, Vol. XXXVII, Pt. 4, 1909.

It is quite possible that a more prolonged search than I was able to give to these beds would produce a better crop of fossils and perhaps result in a find of intermediate horizons.

Agglomeratic slate and Panjal Trap of main range.

For nearly three miles above this point the course of the Sangsofed river is a long, straight, U-shaped valley, (see Pl. 9) cut entirely through the underlying Panjal Trap, and at a level entirely above the forest limit. There are no moraines left along this reach (except a few scanty ones on the south-east side from hanging valleys), owing probably to the rapid retreat of the ice up it, and the subsequent scouring action of the streams. There are, however, a few smoothened rocky hummocks testifying to the passage of ice over them. The valley then breaks up into a branch-work of steeply graded feeders immediately under the final ascent to the passes near Tatakuti, 15,524 feet, of which the Chota Gali Pass, about 14,000 feet, was selected by me to gain the crest of the range. This is not the one marked with that name on the Atlas of India sheet, but another one not more than ½ mile south-east of, and close under, the Tatakuti peaks. The final ascent begins on old soil and grass-covered moraines, but as it continues, all such covering gradually ceases and it becomes necessary to clamber over the quite fresh terminal rubbish heaps at the foot of the névé glacier ice under the summit of the range. The last three quarters of a mile or so is over the upper part of the névé ice to the summit of the pass.

The rock at the summit, and as found in the fresh terminal moraine stuff under the ice, is agglomeratic slate (the horizon of which is immediately beneath the Panjal Trap). It dips 60°N.E., and as my position then was in the direct line of strike of the picturesque double peaks of Tatakuti, it was easy to see that that peak also was similarly composed. Tatakuti and the surrounding lesser peaks have rather jagged summits wrought out of this fine-grained agglomeratic slate; and in the shady hollows among them lie the very diminutive glacier patches, before remarked as characterising the range. In spite of their small size they are very actively at work carrying and pushing the disintegrated debris down the steep slopes, and alternately engaged in filling up or causing equally diminutive tarns among the steep-sided spurs.

General remarks.

This concludes my description of the section along the Nilnag-Tatakuti route. Though not very complete, or well exposed, it is manifestly a repetition as regards its component formations of that described by me at the Golabgarh Pass, 35 miles away to the south-east (*Rec. Geol. Surv. of India*, Vol. XXXVII, pt. 4, 1909, p. 289). It will be observed that the lowest stratum reached in the section is the agglomeratic slate coming beneath the Panjal Traps. This has been shown in my previous reports (*loc. cit.*) to coincide roughly with an Upper Carboniferous horizon, being above the Fenestella series and Syringothyris limestone which are judged to be Middle and Lower Carboniferous respectively, whilst the direct and convincing fossil evidence for the Gondwana plant beds and their successors with *Protoretepora, Lyttonia*, etc., date the upper part of the section with considerable accuracy.

Thus the main range and the north-east flanks here and on the Golabgarh section have been proved to be composed of Carboniferous (including a great thickness of the Panjal Trap) Lower Gondwana, Permo-Carboniferous, Trias and Karewa formations, *and nothing older.* When therefore, as we shall presently see, the same composition in addition holds good still further north-west towards Gulmarg, it seems very difficult to imagine any intermediate points in the range as being composed of radically different elements, such as is required by Lydekker's map.

Apart, however, from what might be considered a debateable question as to whether Lydekker's sequence along his cross sections, or my sequence along mine, should be taken as the more typical of the structure of the Pir Panjal as a whole, the additional matters of fact presented by the Nilnag-Tatakuti section have an interest of their own, not the least of which is the fresh evidence for linking the great Gondwana formation of Southern India with its time equivalents among the Himalayan marine sedimentaries. Whatever my distinguished predecessor may feel with regard to the critical points dealt with in this section, I cherish the hope that he will recognise that I have added something to the "foundation" laid by him—even though it be perhaps with a rather free hand.

Toshmaidan.

Parallel traverse.

From the Nilnag-Tatakuti cross section I proceeded north-west along the range to Toshmaidan, and from there to the Gulmarg-Apharwat section. Under the present heading, therefore, I shall describe the north-east flanks of the range as they were seen in this traverse parallel to the general strike instead of across it.

No detailed delineation.

In doing this it should be understood that I am not depicting a finished bit of geological mapping, a task which I soon found would be premature for the following reasons: (1) the old ¼ inch=1 mile Atlas of India sheets of these slopes are exceedingly imperfect, (2) the vast amount of glacial deposits on the slopes would make an adequate delineation on such a scale very spotty, (3) a new topographical survey on a larger scale is now in progress. For these three reasons I considered it sufficient to aspire only to discovering the true sequence of the rocks, and to putting together a general account of their distribution in place of any detailed delineation work carried out under the present disabilities, especially seeing that the latter will soon be removed.

Chaga and Lal Shah ki Alum.

Toshmaidan was reached with one halting place in between, and after traversing laterally at the 11,000-12,000 feet level across three or four side spurs of the main range with their intervening valleys. The route disclosed no more of the Gondwana and Permo-Carboniferous series, whilst very little even of the central range of Panjal Trap was in actual evidence owing to the drop in the general level of the range at this point, and to the very continuous moraines. Following a course just above the highest forest it was necessary to thread one's way across the long slopes of moraine stuff which stream away from the south-west where the Nurpur and Chor Gali passes lie so flatly with the rest of the range as to make no mark on the horizon. At slightly lower elevations the frayed-out tail-ends of the moraines disappear down the intervening valleys, whilst the side spurs spread out laterally and vertically into the buttresses of Chaga Station and Lal Shah ki Alum, preparatory to descending more steeply to the level of the Kashmir valley. In them are displayed vast thicknesses of Upper Trias limestone dipping rather more easterly than before, namely 60° north-east-by-east, and with only a border on the south-west of some unfossiliferous drab shales. The uniformity of the section as far as it is visible, and the nature of the debris composing the moraines, suggest no change of importance so far, and one is warranted in believing that if we could clear away the moraine covering here and there we should find the rest of the descending section through Permo-Carboniferous, Gondwanas and Panjal Trap revealed in exactly the same order as in the Sangsofed river.

Change of structure.

North-east of Shah ki Alum the gently inclined north-easterly slopes of the range give way and their place is taken by a higher and steeper ridge bordering the Kashmir valley. This begins as the east edge of the undulating Toshmaidan plateau, and is composed of Panjal Trap, apparently faulted up against the north-east edge of the Upper Trias limestone.

Conglomerates and grits.

With the traps are some purple-coloured conglomerates and grits, well exposed in the craggy south-west end of the spur from Toshmaidan Flag and Toshmaidan Tower of the Atlas of India sheet. They are some 300-400 feet thick and dip 60° S. W. On their south-west side they are interbedded with the traps and to the north-east merge into purple grits and slates followed by Panjal Trap again, which continues right through the Toshmaidan peaks and down the steep scarp towards the Kashmir valley. These coarse sedimentaries coming apparently near the upper limits of the Panjal Traps are a new feature in the sequence, and have not so far been correlated in other sections.

U. Trias of Pass N. of Toshmaidan.

A partial exposure of Upper Trias limestone, in continuation of the Chaga and Lal Shah ki Alum spurs, and along the same strike appears to the south-west of the little pass north-west of Toshmaidan at an elevation of about 13,000 feet, all the intermediate outcrops being covered. Corals and crinoids are imperfectly shown in some of the beds of this limestone. Near the pass and presumably faulted junction with the Panjal Traps the limestone is very thin-bedded with a platy structure giving it the appearance of slate, either vertically bedded or dipping at 70°—80° S. W.

Toshmaidan moraines.

The group of three snowy peaks, of 15,132 feet elevation, which lie further to the south-west, and which constitute the summit of the great range at this point, are quite near and directly overlook the green meadows of the Toshmaidan, but the whole of the intervening slopes and the plateau of the Toshmaidan itself are sheeted with moraines, old and grass-covered up to near 14,000 feet, when fresh ones connected with the diminutive glaciers of the present day make their appearance under the main summits.

Panjal Trap of Snowy peaks.

The lines of trend of the old ones seem to show that not only did the extended glacier system that carried them take a curve to the south-east and in the direction of the Suknag river, owing generally to the resistance of the elevated trap ridge already referred to as bounding the maidan in this direction, but also that a certain portion of the ice probably overflowed directly over the edge of the basin through gaps in the ridge north-east towards the Kashmir plain. I did not ascend to the 15,832 feet peaks, inasmuch as being in full view from my camp on the Toshmaidan they promised nothing but moraine stuff right up to the last 1,000 feet or so, and then Panjal Trap only, as was made evident from the content of all the moraines below.

Route from Toshmaidan to Gulmarg.

From the pass north-west of Toshmaidan I found the only feasible route for myself and baggage animals took me straight along the strike to Danwas and from there to the north-east foot of the range near Ferozepur and then back again up the slopes to Gulmarg. This was necessitated by the very deep river bed separating Danwas from Gulmarg. The old Atlas sheet is very defective in the hill-shading here, and gives no hint of the way this gorge has cut back its bed far into the mountain mass. (The inner slopes of Toshmaidan, which are really an undulating almost level expanse are etched in stronger lines on the map than is this profound gorge !). Panjal Trap, so far as visible, extends all the way down the long descent from the pass to Danwas and beyond, still descending, to Drang near Ferozepur where the slackening off of the angle of slope as the level of the Kashmir valley is approached suggests the presence of Karewas, though there are no visible exposures.

General remarks.

In summing up the area just described between the Nilnag-Tatakuti cross section and that of Gulmarg-Apharwat, it seems only necessary to remark that, while the compositional elements remain the same so far as can be seen, a new structural feature is gradually introduced by the strike-fault through the Toshmaidan and the change of dip and order of the beds to the north-east of it.

Gulmarg-Apharwat Section.

The structure along this line of section is illustrated in Plate IV, fig. 2. It was investigated at the close of the season, when I was unable to carry it beyond the "frozen lakes"—two small mountain tarns between the 12,000 and 13,000 feet levels.

Schistose rocks below Gulmarg.

The lower part of the section below Gulmarg is a steep scarp. It has not been examined in detail, but such rocks as are seen along the upper edge are much crushed and sheared, with production of fresh divisional planes and incipient metamorphism. Probably many of these were beds belonging to the Panjal Trap series.

Gulmarg-Kilanmarg moraines.

The vast amount of old grassed moraines at Gulmarg and the similar but steeper forest-covered moraines constituting the slopes between Gulmarg and Kilanmarg and which here and there develop flat "margs" or grazing grounds, must have been derived from the 15,000 feet snowy peaks near Toshmaidan and the Zamar pass. Looking up from Kilanmarg, the valley which runs north from those peaks by Penjian of the Atlas sheet to join the Ferozepur nullah can be seen in its upper reaches to be a typical smoothed U-shaped one, and may well have borne a large glacier. The deep nullah to the south-east of Gulmarg may also have contributed, but it must have been cut down to its present deep level since that time.

The old moraines apparently had their downward limit just at Gulmarg, where was the lowest melting point of the ice. The other grassy flats between Gulmarg and Kilanmarg probably represent stages in the recession of the glaciers.

Panjal Trap.

Continuing the section from Kilanmarg near the tree limit by one or other of the easy routes straight up to the visible summit (marked Pharpat on the Atlas sheet), the solid rock when once the thick moraines are passed is compact and amygdaloidal Panjal Trap, of which the bedding can be seen to dip in towards the hill, that is, west-by-south at about 60°. As the slope is some 3,000 feet high this must represent the thickness visible, but an even larger thickness lies buried out of sight below this.

Lower Gondwanas.

Just beyond the summit, as visible from Gulmarg, following along the narrow neck connecting it with a higher peak (said to be 14,800 feet) beyond, and overlooking the nearest of the "frozen lakes," some purple and then dark shaley or slaty beds, with a lower Gondwana flora and a conglomerate of trap pebbles set in. As there is no vegetation on the ridge these strata are fully exposed, though not indeed everywhere as solid rock, but rather as bruised and shattered edges of what were once vertically bedded strata. The material thus lay approximately *in situ*, and the dark shaley material could be seen wandering down the rubbish-littered slopes to the nearest frozen lake in a more or less well-defined band, approximately 0-100 feet thick.

In the outcrop-fragments picked up along this shattered band were found the following plant remains :—

Gangamopteris sp. in several large, well-preserved leaves.

Noeggerathiopsis sp. in several large not very perfect specimens.

Taeniopteris sp. two large specimens.

Alethopteris cf. *phegopteroides*, Feistm. (see *Pal. Ind.*, Series XII, Vol. III, pt. 2) two specimens, one very clearly outlined on a weathered fragment.

Large thickness of Gondwanas.

Along the connecting ridge for some way west-by-south the overlying continuation of the Gondwanas becomes more arenaceous, with a few calcareous layers, whilst the same, following the route of the frozen lakes in and out among the valley heads, develops into an enormous thickness of finely laminated, slightly metamorphosed shaley sandstones, banded dark and light. On arriving at the second little tarn one has traversed about one mile in thickness of these beds of nearly vertical lie (70°—80°), and the prevailing rock becomes more arenaceous still, almost a quartz-schist in fact.

So far as I could see further in this direction there was no sign of any change, such as probably would have shown at the surface if *Protoretepora* limestone were setting in.

This great local thickening of the Gondwanas is not surprising when we already know how great are the variations of the same beds between Khunmu and the Golabgarh Pass—from almost *nil* to about 800 feet.

Perhaps the route along the Ferozepur Pass would give one some further information as to the ultimate succession, but this descends some 2,000 or 3,000 feet from Apharwat before re-ascending again, and would have required a fresh camp at the intermediate level, for which time and the advancing cold season did not permit.

The "frozen lakes."

The two mountain tarns are very small, a few hundred yards long only, and completely surrounded or rather bedded in a mass of loose moraine and talus rubbish.

General Remarks.

The partial section thus described, though it does not show much, gives us once again a sequence from Panjal Trap through Gondwana plant bearing slates into what may be presumed to be a representative of some of the Gondwana sandstones converted into quartz-schists. It was unfortunate that I could not follow the sequence further to discover whether the Protoretepora shales succeeded this sandstone. Nevertheless, the section so far as it goes is in harmony with the preceding ones; and the only suggestion of the proximity of gneissic or granitic rocks is to be found in the slightly metamorphic character of the arenaceous members of the Gondwana series. As before, no trace in the river gravels or moraines of such plutonic acid rocks is in evidence on this side of the range.

The ascending order of the formations in the Gulmarg-Apharwat section is, however, not from south-west to north-east as in the Nilnag-Tatakuti section, but in the opposite direction. I should surmise from this and also from the general strike at Toshmaidan and the deduced fault along the pass there, that the Gulmarg-Apharwat traps are a strike continuation of those on the north-east edge of the Toshmaidan plateau, but I could not be certain. The whole intermediate tract of country is so dominated by moraines, and so difficult to traverse that it must be reserved for a future occasion, when more time and better maps are available, to work out the full distributional details of the structure. Already when I was there the higher grazing grounds had been deserted by the flocks and herds, Gulmarg was closing for the winter and snow had begun to fall on Apharwat.

Notwithstanding the great thickness of Lower Gondwana deposits developed near the frozen lakes, I found no trace of any carbonaceous material therein beyond what occurs in the dark shale. Considering the fact that the same rocks in Peninsular India carry nearly all the coal of the empire, it might well have been otherwise. It is not likely, however, in consequence of the metamorphism which has been superinduced in these rocks that any real coal could have remained as such, but the possibility of graphite having taken its place should not be overlooked.

Predominance of Panjal Trap in central axis of range.

It will be observed that, combining my observations made in 1908 in the Golabgarh route with those made last season in other parts of the Pir Panjal, one very characteristic feature stands out prominently—namely, the large part played by the Panjal Trap in the composition of the central axis of the range. Though only shown by Lydekker as two narrow strips on the two lower margins of the mountain mass, it is now certain that over very great lengths, aggregating 40 miles between the Golabgarh Pass and Baramullah gorge, and with enormous thickness, this formation either actually builds the more prominent peaks such as those of Brama Sakal, Naba Pir, the large group of unnamed 15,000 feet peaks south-west of Toshmaidan and Apharwat, or it is a supporting backbone quite adjacent to them as in the Tatakuti mass.

The name "Panjal Trap" is therefore more strikingly appropriate for this mass of basic lavas than Lydekker supposed when he instituted the name. It has therefore been retained by me.

Retention of the name.

On the other hand the expression "Panjal slates," already sufficiently discredited, must now be dropped altogether, inasmuch as in other parts of Kashmir Silurian and older rocks have been included under this name and here Carboniferous to Trias, whilst, as I have just shown, much of the area so coloured in the Panjal Range is not slate at all but massive Trias limestone.

The name "Panjal slates" discarded.

These necessary changes in nomenclature had already been effected in my previous paper on the revision of the Silurian-Trias sequence.

Reconciliation with Lydekker's Descriptions.

Having discussed in the previous pages the features in which my survey of the Pir Panjal region differs from Lydekker's, a few words may well be devoted to showing how the two may be reconciled with each other. This seems to be equally obligatory for a fair and dispassionate statement of the case.

From Lydekker's early paper in the *Records* (Vol. IX, p. 155) and his final memoir (*loc. cit.*) it is evident that his traverses across the range were by (1) the Baramullah gorge, (2) the Gulmarg-Nilakanta Pass, (3) the Pir Panjal Pass, and (4) the Banihal Pass.

Let us first consider the evidence for the granitoid gneiss core and its metamorphic aureole. In his memoir (pp. 213-217 and 290, *et seq.*) he describes finding the former as boulders in the bottom of the valley in route 1, and *inferred* its presence in the range on the south-east side. In route 2 he admits there was no granite or gneiss, etc., and so has omitted it in the map. But in route 3 his evidence for it occurring in the Pir Panjal Pass is so circumstantial that it cannot be doubted. He categorically states (p. 215) that immediately above Aliabad Sarai fine-grained granitoid gneiss with a few bands of schist and quartzite are found, and that they continue nearly to the summit of the pass, where the gneiss is in almost vertical beds. In route 4 it must also be conceded that it was found, though much to the south-west of the main range. Between the last two passes I have myself recorded it in a band between Angril and Dowal, but here also it is south-west of the range again.

The gneissose core of the range therefore has a real existence somehow and somewhere, but with the following restrictions:—Even with its metamorphic aureole it must be much narrower in outcrop than represented by Lydekker. It must also be confined to the south-west scarps of the main range as a whole, with the single exception of a short strip of country between the points noted by me south-west of the Golabgarh Pass and the Pir Panjal Pass where, owing to the temporary sharp curve southwards of the line of peaks and passes, the granitoid rock and its metamorphic zone once, and once only, cut and occupy the watershed for a length of about 12 miles in a total distance from the Banihal Pass to the Baramullah gorge of about 90 miles.

Beyond the Pir Panjal Pass by Tatakuti to Apharwat granitoid rock certainly does not occupy the crest of the range, though it may still be found perhaps on the south-west scarps again—there being no positive evidence on this point.

With regard to a portion of Lydekker's metamorphic series and the whole of his Panjal slates, etc., on each side of the gneissose core, the readjustments in the matter of terms necessary since Lydekker's time has been shown to be chiefly dependent on the evidence afforded by fossils, whereby some of these slightly metamorphosed strata and slaty rock must be classed with one and some with another horizon in the geological record, but all certainly of much younger age than Silurian (or older) as contemplated by Lydekker. We may reconcile his descriptions as follows: in route 1, Lydekker's flaggy slates, sandstones and grits said to be schistose south of Gingal, must be relegated to my Gondwanas. In route 2 his slate and sandstone rocks with amygdaloidal trappean rocks are obviously the same Gondwanas *plus* Panjal Trap. In route 3 the same are indicated *plus* my agglomeratic slate (his black slate with pebbles and boulders) among which the granitoid gneiss appears; and a similar explanation holds good for route 4 by the Banihal Pass.

It now only remains to account for the omission in Lydekker's sections of the Permo-Carboniferous and thick masses of Trias limestone formations, which under the name of Kuling and Supra-Kuling were perfectly familiar to Lydekker in other areas. They have been located by me at the Golabgarh Pass and continuously between Ludar Marg and the pass north-west of Toshmaidan, localities which are unmentioned by Lydekker and were probably not seen by him. But elsewhere along the sections traversed by Lydekker it may well be that these rocks were either hidden by Karewas, as perhaps in the Pir Panjal pass route near Hirpura, or by moraines at any point; or they are actually absent as in the Baramullah gorge and the Gulmarg-Tatakuti section.

Thus when Lydekker's mapping is brought down to its lowest terms, namely, that of the points personally visited by him, there is but little to complain of. His mistakes and omissions then become such as are common in a preliminary survey, and are simply due to too free interpolation between known points over long distances. His work has not been lost, and there now emerges from our combined surveys a much more full (though by no means yet perfect) account of the geological structure of the Pir Panjal. This I have attempted to generalise in the sketch map (Plate 11), omitting the surface glacial deposits.

The Pir Panjal and Mountain Evolution.

A result of some general interest following on the discovery of the much younger age of the rocks forming the Pir Panjal range is connected with the zonal evolution of the mountain area of Kashmir as a whole.

When working out the structure of the neighbouring district of Hazara (see *Mem. Geol. Surv. of India,* Vol. XXVI, 1896) the present writer was able to group the formations of that region into four chief zones, which stretching from the plains to the high tracts of Khagan and the Black Mountain were (1) the Sub-Himalayan zone, (2) the Nummulitic zone, (3) the Slate or Abbottabad zone, and (4) the Crystalline and Metamorphic zone. Each of these was shown to be separated by a long sinous fold-fault or thrust-plane from the next to the north, and to be younger as regards its composition and date of folding than it. This mode of folding in blocks, separated by major fold-faults, the general inclination of the strata being in one direction, may perhaps be spoken of as successive zonal imbrication.

But in spite of the most perfectly clear evidence of "syntaxis"[1] of the axes of the folds along the lower reaches of the Jhelum, where it cuts through these zones separating the two mountain areas of Hazara and Kashmir, belonging respectively to the Hindu Kush and Himalayan arcs, it was at that time impossible to see in Kashmir, east of the river parting, any exactly similar successive zonal arrangement (see pp. 271, 272 of my Hazara memoir); since, among other reasons, the rocks composing the Pir Panjal seemed to be as old or older than those to the north across the Kashmir valley (although even at that time doubts as to the age and oneness of the Panjal system had begun to be felt among Indian geologists).

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[1] Suess, *Face of the Earth,* Vol. I, p. 421, authorised English translation by H. B. Sollas. The original word *Schaarung* has been rendered thus.

But the Pir Panjal as we now regard it, composed of much younger rock elements, and forming a zone by itself, sharply contrasted with the next zone to the north-east, makes possible a three-fold division at least of part of Kashmir on a similar plan, namely (progressing from the plains as before) (1) the Sub-Himalayan and Nummulitic zone combined, (2) the Pir Panjal or Carbon-Trias zone, and (3) an older zone or zones, containing large areas of rocks of Silurian age.

Thus Drew's original division of the ranges of Kashmir into Outer Mountains (Sub-Himalayan), Middle Mountains (Pir Panjal) and Inner Mountains, besides having a geographical and ethnological significance, is now seen to express important differences of innate geological composition and structure; so that here too, as in Hazara and other parts of the Himalaya, we can detect a clearly marked successive zonal imbrication, which cannot but imply a gradual and successive development of the mountain area.

There can be no doubt that one factor contributing to give an aspect of moderate youth to the Pir Panjal range or mountain block, is its geologically late veneer of Karewa sediments, which sheet in much of its northern flanks and cause the beautifully graceful sweep of its slopes down to the Kashmir valley.

This should not be dismissed as a mere superficiality; since, without the Post-Karewa tangential movements of the range which those sediments embody, the angle subtended by the central peaks would be sufficiently smaller to damage seriously their present importance. Besides, even as a Post-Pliocene embellishment or rejuvenescence of the Pir-Panjal mountain block, they require consideration in appraising the general age and architecture of the region.

The full consideration of these and many other interesting problems must await further knowledge and the issue of better topographical maps.

II. SECTIONS IN THE SIND VALLEY.

Introduction.

Line of route.

The route up this side valley and over the Zoji La (pass) is a well known one. It not only leads to the summer resort of Sonamarg, but it is also one of the most frequented high roads into Central Asia *viâ* Kargil and Baltistan, and to the mighty range of the Karakoram Himalaya. It furnishes excellent sections to the geologist along an easy line of approach, and supplements those along the Lidar, Arpat, Maru Wardwan, etc , parts of which I have already described in my previous papers.

Part of Lydekker's Kashmir basin.

It will be seen from Lydekker's map and description that this line of country intersects the upper end of the northern division of the Kashmir basin of that author. This basin of younger palæozoic and mesozoic rocks lies further away from the Kashmir valley than any of the parts so far described by me, and is involved in foldings whose axes pass completely outside and to the north-east of those sections.

Similarity of section to others already described.

Still it was sufficiently near to those sections to cause me to expect a certain similarity to them, a similarity which I thought likely to be carried out even in the matter of the mistakes made in interpreting them.

Mistake of interpretation at Gagangair.

In selecting it for revisiting I was chiefly attracted by the position just above Gagangair and on the Zoji La, where it seemed to me that, according to the later light shed on the age and position of the Panjal Trap, there must be a mistake in Lydekker's interpretation. In particular his doubled band of Kuling limestone, etc., separated by Panjal Trap, inevitably suggested to me a replica of the Lidar valley error. I confidently expected to find the south-west band to be the Syringothyris limestone and the north-east one to be Permo-Carboniferous, instead of the two being one and the same band repeated by an isoclinal fold (see pp. 144-147 of Lydekker's memoir and Plate III, fig. 4 of the same).

This was my practically certain conclusion before arriving at the section, whilst in addition I was rather sceptical as to the curious

Z-shaped outcrop of Panjal (Silurian) slates represented by Lydekker as a distorted anticlinal dome among the wide area of Upper Trias (Supra-Kuling) limestone above the Zoji La.

The following details which I was able to collect last summer will be of interest as confirming those prognostigations. I may remark that little credit attaches to the discovery of these new facts since, knowing just where they must be (if my conjectures were correct) I found it a comparatively easy task to spot them in the field. In view of the changes in the map thus made evident a short account seemed called for in continuation of my two previous papers dealing with similar problems.

Section below Gagangair.

Silurian slates.

Below Gagangair (Gaggangan of Atlas sheet) the lower reaches of the Sind valley, marked as Panjal slates with Panjal Trap in certain parts, must be understood to be Silurian and older gnarled slates, phyllites and greywackes, with rare calcareous layers, and with Panjal Trap unconformably overlapping them. The trap has been shown in my previous paper (*Rec.*, Vol. XL, pt. 3) to mark at its base a line of considerable unconformity or overlap of all the intermediate series, and therefore there is no anomaly in finding it here lying directly upon the really ancient slaty series.

The gnarled slates frequently show a quasi-foliation and lenticular shearing which, cutting at angles with the original bedding planes, makes a wavy somewhat contorted effect with development of secondary mica films along the directions across the bedding. All are of pale drab colours as a rule. They contain no fossils so far as my investigations went, but frequently ferruginous patches as found in the type areas, and which may once have been fossils.

Biotite-granite intrusions.

The biotite-granite intrusions in these slates near Margund need not detain us long, as no new facts of interest were elucidated by the valley sections. It is not very gneissose, and apparently runs as a laccolite or bed up the face of the hill above Margund. Next to it occur well metamorphosed mica schists and quartz schists, the latter furnishing mill-stones.

Forest covered slopes.

As in the type region of the Lidar valley and valleys to the south-east, the Sind valley through this series of altered slates and greywackes is fully covered with forest on the slopes facing north, and barer on the southward facing slopes.

Gagangair Section.

I now proceed to the Gagangair section, (Pl. 12, fig. 3) and shall mention in brief detail the now-ascertained facts of composition and succession that render the new interpretation there the only one possible.

Muth quartzite.

A quarter of a mile above Gagangair, and exactly where a small side stream descends south-east from Shatian Station (14,356 feet), the thin-bedded Silurian slates are succeeded in characteristic way (just as at Gugaldar, Hairbal Gali and Gudramer described in my last paper) by a rather thin but very typical outcrop of the massive Muth quartzite. It is only a few hundred feet thick, but it may be seen on both sides of the Sind valley dipping in huge slabs at about 60° north-east.

No Upper Silurian fossils.

The base of this and the uppermost beds of the slates were searched most carefully up the side stream referred to above for the Upper Silurian band of Orthis slates, but without avail.

Syringothyris limestone.

The limestone series which succeeds the quartzite and which has been marked as the outer Kuling band by Lydekker is about 200 feet thick, and is only accessible on the Gagangair side of the valley (right bank) either by climbing up a steep talus slope of about 1,000 feet in the main valley or of 2,000 feet in the side stream. It appears to follow conformably on the quartzite. By detailed work along the base of the cliffs above the talus slope some fossils were extracted, not very numerous and much crushed, but sufficient to identify the bed.

The following were rather arbitrarily identified, not so much on their own merits, as by their resemblances to the better preserved examples found at Eishmakam, etc., under similar conditions as regards sequence and condition of the beds: *Syringothyris cuspidata* Mart., *Productus lineatus* Waag., *Aviculopecten, Athyris.*

Fenestella shales and agglomeratic slate.

A mere trace of the Fenestella shales with *Fenestella* was found and they are succeeded by dark grits and agglomeratic slate, many fragments of the latter being found on the roadside under the cliffs at the great bend of the river before the Panjal Trap gorge is reached. The thickness of these was not determined but they are relatively thin.

Panjal Trap.

Next follows the precipitous crags of the Panjal Trap, still dipping in the same normal way at 70° N.E. and building the formidable precipices of the Shatian ridge, on the north-west side of the gorge and (on the south-east side of the gorge) the great slopes with hanging glaciers south-west of the Dharnar valley. It is through these that the narrow, and deep gorge part of the Sind above Gagangair has been cut. There must be laid bare as much as 6,000 feet of this characteristic and striking formation.

Identity of section with that of Lidar valley, etc.

With a sequence of ancient slates below, followed in turn by (1) Muth quartzite, (2) Syringothyris limestone, (3) traces of the Fenestella shales, (4) good examples of the characteristic agglomeratic slate, and (5) by the thick masses of the Panjal Trap, that is to say, by five formations in order, composition and (so far as they go) fossil content identical with those of the type sections in the Lidar, Gugaldar, Harpatnar and Naubug valleys, there can be no doubt whatever of my interpretation of the section being correct. And when in addition these are followed by a sequence of shales and limestones certainly involving Muschelkalk and the very thick and massive Upper Trias (Supra-Kuling of Lydekker) it may be presumed that the demonstration is complete. The latter part of the section I will now describe.

Sonamarg-Zoji La Section.

Doubtful representatives of the Permo-Carboniferous and L. Trias.

As the deep gorge in the Panjal Trap is left behind and we enter the wider valley of Sonamarg at an elevation of about 9,000 feet the striking dip slopes of the Panjal Trap end on the right bank of the Sind immediately opposite the Thajwaz camping grounds, and are followed without any change of dip by deeply eroded imperfectly exposed pale sandy and schistose slates, (phyllites) about 600 feet thick. No fossils were found in them, and it is uncertain whether any of them really represent Gondwanas, Permo-Carboniferous or Lower Trias. It is therefore possible (1) that these formations are hidden by talus, (2) that any one or more are there, but unfossiliferous, or (3) that they are altogether absent, and that the Muschelkalk is the first formation to occur. The last possibility seems very likely to be correct when we consider the Pailgam section at Pailgam, where only very feeble traces of Permo-Carboniferous beds were found (*Records*, Volume XXXVII, part 4, 1909).

Muschelkalk found *in situ*.

That the Muschelkalk occurs here or hereabouts had been surmised from the finding by Stoliczka of *Ptychites* at Thajwaz (see Lydekker's memoir, page 146) and from other fragmentary evidence summarised in my last paper (*Records*, Volume XL, page 248), and it has now been corroborated by my getting one recognisable specimen of *Ptychites* and numerous other fragments of ammonites and gastropods and black lumps with traces of ammonite sutures here and there from the phyllites and ochre-coloured calcareous bands, about 200 feet thick, immediately succeeding the pale schistose sandy beds last described, and at the position shown in the section Plate 12, fig. 3. Above these come about 400 feet of black shales, making in all about 1,200 feet of these thin bedded rocks before we enter on the thick massive limestone series with occasional crinoid and coral remains of Upper Trias age which continue the whole of the rest of the way up the Sonamarg valley to Baltal (10,000 feet).

Poor locality for fossils.

It is obvious that the metamorphism and crushing to which these rocks of Muschelkalk age have been subjected have destroyed all chance of getting a good collection of organisms from them. So, beyond the proving of the age of the beds by the fragmentary remains detailed above, I now conclude that further hopes of improving on or even equalling those made last year at Pastannah must be abandoned in this northern division of the Kashmir basin.

The same thin-bedded series is traceable at intervals in the bed of the Dharnar valley, but the exposures are not good.

Zoji La exposures.

As regards the complicated exposures on the Zoji La (11,300 feet), the massive Upper Trias limestones become thinner bedded on the way up from Baltal, and also interbedded with black shale or much crushed slate with pyrites. Foliation with mineral change seems to have split these rocks parallel to the bedding, giving a very fissile rock incapable of holding good fossils.

Muschelkalk repeated by folding.

At further points on the route to the pass where the track winds along rock galleries hewn out of the cliff-side occur more calcareous layers, with black lumps suggestive of ammonites, and others certainly the remains of ammonoid forms. Many were much distorted, being drawn out into long pencils of black limestone amongst the schistose slate matrix. I conclude therefore that there is much reduplication here in these Upper Trias beds with faulting bringing up the Muschelkalk again and again.

Panjal Trap.

Finally, quite close to the pass on the slopes to the south-east appeared a debris cone of blocks of ordinary Panjal Trap descending from the slopes above Sokanag, where it can be seen *in situ* in a much crushed fold. There was not much of this, however, and, so far as the eye could see, and including the Somelo Station hill, 16,934 feet, the ordinary limestone with shaley partings (Upper Trias) seemed to continue.

I believe the whole position here is simply the same as already described by me between Khrew and Zantrag and above the latter up to the higher hills to the north-east (see *Records*, Volume XL, page 252), that is to say, the Zoji La section is a series of reduplicated and inverted folds among the Upper Trias with an unknown amount of faulting.

It is my opinion therefore that I saw no evidence there, either for higher rocks than Upper Trias (Spiti shales or Gieumal sandstone of Jura-Cretaceous age) or for much lower beds such as the Silurian slates, which have been marked by Lydekker in that strangely occurring anticlinal.

General remarks.

The prevailing structural features of the section in the higher parts of the Sind valley, therefore, appear to be a repetition of those in the Lidar. Instead of isoclines, a uniform ascending series, from some way below Gagangair to above Baltal, seems proved : it becomes in fact another example of a zone of uniformly inclined beds with imbricate structure. This probably only extends as far as the Zoji La, somewhere beyond which place the zone must end, probably in a series of fractures and reversed folds "in cascades."

In this latter feature also the section repeats the peculiarities of the Lidar Carbon-Trias zone. The section figured in my second paper on Kashmir (*Rec. Geol. Surv. of India*, Vol. XL, Plate 29, fig. 2) shows the beginning of similar "cascade" folds in the Upper Trias north-east of Pailgam.

In this brief epitome of alterations necessary in the map of the Sind valley, I have not touched on the subject of glacial geology. Some few facts with views and sections gathered by me in continuation of the interesting descriptions by R. D. Oldham (*Rec. Geol. Surv. of India*, Vol. XXXI, Part 3) must remain over for the present.

EXPLANATION OF PLATES.

PLATE 9.—View south-west up Sangsafed river to near Tatakuti peak. Old moraines are seen occupying the foreground. The near part of the hill in shadow is Permo-Carboniferous. The rest of the rocks seen are Panjal Trap with agglomeratic slate building the distant summits.

PLATE 10.—View south east up Dharnar valley from Thajwaz camping ground. The line of the valley is the junction of Panjal Traps (on right) with Muschelkalk, etc. (on left).

PLATE 11.—Geological sketch map of part of Pir Panjal.

PLATE 12.—Sections

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THE MINERAL PRODUCTION OF INDIA DURING 1910. BY H. H. HAYDEN, B.A., F.G.S., *Director, Geological Survey of India.*

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I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these *Records* (Vol. XXXII), although admittedly not entirely satisfactory, is still the best that can be devised under present circumstances. The methods of collecting the returns are becoming more precise every year and the machinery employed for the purpose more efficient. Hence the number of minerals included in Class I for which approximately trustworthy annual returns are available—is gradually increasing, and it is hoped that before long the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will be reduced to a very small number. In the case of minerals still exploited chiefly under primitive native methods and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible, but the total error from year to year is not improbably approximately constant and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. The chief minerals falling under this category are iron-ore and tin-ore. In the case of gold, the small native alluvial industry contributes such an insignificant portion to the total outturn that any error from this source may be regarded as negligible. The opening of the Tata Iron and Steel Works in the near future will probably bring the returns for iron-ore into a similar position.

Total value of production.

The annexed table (Table 1) shows the values of the chief minerals produced in 1910 as compared with the values for 1909. Last year, for the first time since the year 1898, there was a fall in the total value, amounting to 4·6 per cent., and it is satisfactory to see that this has once more been converted into a rise, although the total value is still below those for 1907 and 1908. The chief minerals of which the outputs for the year under review show a decrease in value are coal, petroleum, saltpetre and jadestone, whilst there have been marked rises in manganese, salt, mica, lead and wolfram. In the case of coal the decrease in value, amounting to 12 per cent., must be set off against an increase of 1½ per cent. in quantity.

TABLE 1.—*Total value of Minerals for which Returns of Production are available for the years 1909 and 1910.*

	1909.	1910.	Increase.	Decrease.	Increase or decrease per cent.
	£	£	£	£	
Coal	2,779,865	2,455,544	..	324,321	— 12
Gold . . .	2,204,866	2,202,486	..	2,380	— 0·1
Manganese-ore (*a*) .	603,908	849,455	245,547	..	+ 40½
Petroleum . . .	910,172	835,927	..	74,245	— 8
Salt (*b*) . . .	453,630	565,078	111,448	..	+ 25
Saltpetre (*c*) . .	296,838	230,615	..	66,223	— 2¼
Mica (*c*) . . .	156,199	177,152	20,953	..	+ 13½
Lead and lead ore .	74,228	163,022	88,794	..	+119
Jadestone (*c*) . .	84,450	64,747	..	19,703	— 23
Ruby, sapphire and spinel.	58,649	58,849	200	..	..
Tungsten-ore . .	14,000	38,873	24,873	..	+178
Graphite . . .	12,529	20,479	7,950	..	+ 63
Tin and tin-ore . .	9,645	18,578	8,933	..	+ 92
Iron-ore (*d*). . .	16,563	9,811	..	6,752	— 41
Silver. . . .	2,996	4,968	1,972	..	+ 66
Chromite . . .	7,737	2,315	..	5,422	— 70
Magnesite . . .	196	1,382	1,186	..	+600
Diamond . . .	1,089	590	..	499	— 46
Amber . . .	287	283	..	4	— 1½
Total .	**7,687,847**	**7,700,154**	511,856	499,549	+ **0·16**
			+ **£12,307**		

(*a*) Value f. o. b. at Indian ports. (*b*) Prices without duty.
(*c*) Export values.
(*d*) For provinces other than Bengal, values estimated approximately.

The values of the iron and chromite produced have also fallen by 41 and 70 per cent. respectively, whilst there has been an insignificant decrease amounting to 0·1 per cent. in the gold production, due to the closing down of the Dharwar mines during the year. These decreases, however, have been counterbalanced by the rise in production of graphite, tin, silver and magnesite. With the exception of the decline, amounting to 8 per cent., in the value of the petroleum output, the figures generally show a steady rise indicative of healthy industrial progress.

Mineral concessions granted.

Six hundred and thirty-five mineral concessions were granted during the year as against 693 in 1909. The decrease, however, is not of any serious import and is due partly to a falling off in the number of exploring licenses asked for and partly to the fact that only 6 mining leases were taken out for chromite in Baluchistan as against 76 in 1909. There was a small increase, from 394 to 401, in the total number of prospecting licenses granted. In the Central Provinces the numbers fell from 245 in 1909 to 176 in 1910, whereas in Burma they rose from 73 to 156. This latter rise is attributable to the beginning of a rush for tin and wolfram properties in Tavoy and Mergui, the result being increases of 92 and 178 per cent. in the value of the output of these two minerals respectively. It is interesting to note that in spite of the large outturn of tungsten-ore (wolfram), no mining leases for that mineral were taken out during the year; the whole output was presumably won under prospecting licenses.

II.—MINERALS OF GROUP I.

Chromite.
Coal.
Diamonds.
Gold.
Graphite.
Iron-ore.
Jadeite.
Magnesite.
Manganese-ore.
Lead-ore.
Mica.
Petroleum.
Ruby, Sapphire and Spinel.
Salt.
Saltpetre.
Tin-ore.
Tungsten-ore.

Chromite.

There was a fall of 81 per cent. from 9,250 tons[1] in 1909 to 1,737 tons in 1910, in the production of chromite. None was produced in Mysore and the production in Baluchistan fell from 4,325 tons to 1,737. This was due no doubt to the continuance of low prices, the current market rate of £2-7-6 c. i. f. London, being too small to permit of any substantial profit on a commodity which suffers from the disadvantage of such a long lead from mine to seaboard. The rush for mining leases in Baluchistan during 1908 and 1909, which resulted in the grant of 76 leases during the latter year, has not led therefore to any development of the industry; such development indeed could hardly have been expected, since not a single prospecting license for chromite has ever been taken out in Baluchistan and most of the properties would therefore seem to have been taken up merely on chance.

---

[1] Unless otherwise stated the ton referred to in this Review is the long ton of 2,240 lbs.

TABLE 2.—*Quantity and Value of Chromite produced in India during 1909 and 1910.*

Province.	1909.		1910.	
	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£
Baluchistan	4,325	5,767	1,737	2,315
Mysore	4,925	1,970	*Nil.*	..
Total .	**9,250**	*7,737*	**1,737**	*2,315*

Coal.

Total production.

In the previous Review Mr. LaTouche had to record, for the first time since 1882, a decrease—which amounted to 7 per cent.—in the total quantity of coal raised during the year: this was of course the effect of over-production during the boom of 1907-08. There are now signs, however, that the industry has recovered from the check which was inevitable and the increase in outturn from 11,870,064 tons to 12,047,413 tons, although amounting only to $1\frac{1}{2}$ per cent., indicates once more a healthy rate of expansion. This view is borne out by the steady fall in pit's mouth value of Bengal coal, the cost having dropped from Rs. 3-4-0 in 1909 to Rs. 2-12-9 in 1910, a figure more in accord with the prices ruling prior to the boom.

TABLE 3.—*Origin of Indian Coal raised during 1909 and 1910.*

—	Average of preceding five years.	1909.	1910.
	Tons.	Tons.	Tons.
From Gondwana coal-fields	10,379,762	11,463,299	11,635,540
From Tertiary coal-fields	417,644	406,765	411,873
Total .	..	**11,870,064**	**12,047,413**

TABLE 4.—*Average price (per ton) of Coal extracted from the mines in each Province during the year 1910.*

Province.	Average price per ton. Rs.	A.	P.
Assam	4	12	0
Bengal	2	12	9
Rajputana (Bikanir)	3	7	0
Central India	2	13	0
Punjab	5	15	0
Baluchistan	10	5	0
Central Provinces	3	12	0
Nizam's Territory	6	5	0
Others	5	0	0

Exports

Further evidence of improvement in the industry is to be seen in the marked increase, amounting to nearly 43 per cent., in the exports of Indian coal and coke :

TABLE 5.—*Exports of Indian Coal.*

——	1909.	1910.
	Tons.	Tons.
Aden	3,460	7,383
Ceylon	312,507	521,596
Straits Settlements	128,371	235,885
Sumatra	79,394	100,211
Other countries	38,822	121,479
Total	**562,554**	**986,554**
Coke	1,386	1,812
Total of Coal and Coke	**563,940**	**988,366**

Imports.

An equally good sign is the large decrease—36 per cent.—in the amount of coal imported during the year. This is due chiefly to the complete extinction of imports from Japan and the reduction by nearly 50 per cent. and by 80 per cent. respectively, of the amounts imported from Australia and Natal: —

TABLE 6.—*Imports of Coal, Coke and Patent Fuel during 1909 and 1910.*

	1909.	1910.
	Tons.	Tons.
From Australia (including New Zealand)	54,792	28,040
Natal	91,907	18,224
United Kingdom	290,719	244,215
Other countries	32,470	8,480
Total	**469,888**	**298,959**
Coke	14,070	7,977
Patent fuel	6,456	9,060
Government stores	29,567	16,625
Total	**519,981**	**332,621**

Provincial production

With the exception of the Central Provinces, Eastern Bengal and Assam and the North-West Frontier Province—the last being negligible—all the coal-producing provinces show an improved outturn.

TABLE 7.—*Provincial Production of Coal during the years 1909 and 1910.*

Province.	1909.	1910.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Baluchistan	52,449	52,614	165	..
Bengal.	10,660,811	10,778,530	117,719	..
Central India . . .	121,496	130,400	8,904	..
Central Provinces . . .	238,100	220,437	..	17,663
Eastern Bengal and Assam .	305,563	297,236	..	8,327
Hyderabad	442,892	506,173	63,281	..
North-West Frontier Province	96	90	..	6
Punjab	37,208	49,189	11,981	..
Rajputana (Bikanir) . .	11,449	12,744	1,295	..
Total . .	**11,870,064**	**12,047,413**	*203,345*	*25,996*

Gondwana fields.

About 97 per cent. of this increase is attributable to the Gondwana fields, the rate of increase in production amounting to one per cent. in Bengal and to as much as 14·3 per cent. in Hyderabad. About 98 per cent. of the Bengal increase was produced by the Raniganj field, the output of which increased by 4½ per cent.: there was a small decrease, amounting to a little over ½ per cent, in the Jherria output and a decrease of 3½ per cent. at Giridih. A small quantity of coal was won from the Hingir-Rampur field in Sambalpur District. This field was first described by Dr. V. Ball in *Records*, Vol. VIII, pt. 4, (1875), and subsequently a detailed survey of part of it was made by the late Mr. G. F. Reader (*Mem., Geol. Surv. India*, XXXII, pt. 2).

TABLE 8.—*Output of Gondwana Coal-fields for the years 1909 and 1910.*

Coal-fields.	1909.		1910.	
	Tons.	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
Bengal—				
Daltonganj . . .	84,290	·71	84,996	·70
Giridih	704,593	5·93	679,304	5·64
Jherria	5,832,672	49·14	5,794,616	48·10
Rajmahal . . .	1,900	·04	2,788	·05
Ramgarh-Bokaro . .	2,544		3,390	
Raniganj . . .	4,034,812	33·99	4,212,606	34·98
Sambalpur (Hingir-Rampur).	..	..	830	
Central India—				
Umaria . . .	121,496	1·02	130,400	1·08
Central Provinces—				
Bellarpur . . .	85,237	·72	93,276	·77
Pench Valley . . .	92,196	·77	87,677	·73
Mohpani . . .	60,667	·51	39,484	·33
Hyderabad—				
Singareni . . .	442,892	3·74	506,173	4·20
Total . .	**11,463,299**	**96·57**	**11,635,540**	**96·58**

Tertiary fields.

The outturn of the Tertiary coal-fields shows a slight increase, the decline of 8,469 tons in the output of the Margherita collieries being more than counterbalanced by a rise of nearly 12,000 tons in the Salt Range fields. There has been a small increase, which will probably be more marked in 1911, in the output of the Palana colliery in Bikanir. In Assam, small quantities of coal are won from the outcrops in the Sibsagar and Jaipur Districts and are used locally in the tea factories; outside Makum, however, no definite industry has yet been established, although an attempt is now being made to undertake serious mining in the Jaipur field. The recent discovery by Messrs. Pascoe and Webster of valuable coal-seams in the Namchik river to the east of Margherita will probably result in further developments in this part of the belt of coal-measures.

In the Punjab a decrease of outturn may be expected in the near future, since the North-Western Railway Company have decided to close down Dandot colliery and give up the use of Salt Range coal. Hitherto the coal-seams have been worked almost entirely from the southern scarp of the range and an attempt is now being made to ascertain by boring whether thicker and better coal exists further to the north under the wide plateaux which form the top of the range. The first experiments will be made on the Dilwal plateau, a few miles to the N.-N.-W. of Dandot.

TABLE 9.—*Output of Tertiary Coal-fields for the years 1909 and 1910.*

Coal-fields.	1909.		1910.	
	Tons	Per cent. of Indian Total.	Tons.	Per cent. of Indian Total.
Baluchistan—				
Khost . . .	40,237	·34	43,428	·36
Sor Range, Mach, etc. .	12,212	·10	9,186	·08
Eastern Bengal and Assam—				
Makum	305,563	2·57	297,236	2·47
North-West Frontier Province—				
Hazara	96	·32	90	·41
Punjab (Salt Range)—				
Jhelum District .	34,135		46,655	
Mianwali . .	45		1,884	
Shahpur . .	3,028		650	
Rajputana—				
Bikanir	11,449	·10	12,744	·10
Total .	**406,765**	**3·43**	**411,873**	**3·42**

Consumption of coal.

The ratio of Indian coal consumed to coal produced fell considerably, from 95·3 per cent. in 1909 to 91·8 in 1910, the exports thus amounting to

8·2 per cent. 3,823,394 tons of coal were consumed on Indian railways, being an increase of 58,080 tons over the consumption of the previous year; the percentage of foreign coal in this total fell from 2 to a little under 1·4.

Labour.

There has been a marked increase in the outturn per person employed in almost every province, and although the total output of coal has increased by over 177,000 tons the number of persons employed daily has been reduced by over 3,000. The result is that 103·7 tons have been produced per person employed as against 99·3 in 1909; for the Bengal coal-fields the average is 109·7 tons per person, which compares favourably with 104·3, the figure for 1909. This increased efficiency is due no doubt to more extended use of mechanical appliances, and is even more marked if it be represented on the basis of the ratio of persons employed *below ground*, in which case the figure becomes 171·9, which shows a very considerable advance on 163·1 and 153·5, the figures for 1909 and 1908 respectively.

TABLE 10.—*Average number of persons employed daily in the Indian Coal-fields during 1909 and 1910.*

	Number of persons employed daily.		Output per person employed.	Number of deaths by accidents.	Death-rate per 1,000 persons employed.
	1909.	1910.	1910.	1910.	1910.
			tons.		
Baluchistan	1,105	1,073	49·03	4	3·72
Bengal	102,253	98,281	109·7	124	1·26
Central India	1,505	1,398	93·3	1	·71
Central Provinces	2,911	2,419	91·1	2	·82
Eastern Bengal and Assam.	1,795	1,925	154·4	27	14·02
Hyderabad	8,517	9,031	56·05	16	1·77
North-West Frontier Province.	4	5	18	..	..
Punjab	1,223	1,782	27·6	3	1·66
Rajputana	233	167	76·3	..	..
Total	**119,546**	**116,081**	..	**177**	..
Average	..	..	**103·7**	..	**1·5**

Diamonds.

There was a marked decline, amounting to over 47 per cent. in weight and 46 per cent. in value, in the output of diamonds during the year. The weight obtained in Central India increased whilst the value fell by nearly 50 per cent. The outturn from Madras was insignificant. The average number of persons employed daily in the industry is returned as 546 in Central India and 128 in Madras.

TABLE 11.—*Quantity and Value of Diamonds produced in India during 1909 and 1910.*

	1909.		1910.	
	Quantity.	Value.	Quantity.	Value.
	Carats.	£	Carats.	£
Central India . . .	35·98	1,042	62·24	577
Madras	111·375	47	15·5	13
Total .	**147 355**	*1,089*	**77·74**	*590*

Gold.

There was a slight fall in the production of gold, amounting to 1,696 ounces. This is to be attributed largely to the closing down of the Dharwar mines, the output of which was only 737 ounces as compared with 5,616 in 1910. This was partly compensated by the opening of the Anantapur workings, which have produced 2,532 oz. There were slight increases in the outputs in Hyderabad and Mysore, but a decrease of nearly 30 per cent. in the amount of alluvial gold won in Myitkyina.

The returns for the alluvial industry in the Punjab, United Provinces, Kashmir and Pakokku are admittedly inaccurate, and probably too low, but, as they represent only an insignificant fraction of the industry, their effects on the totals are negligible and, in any case, the error is probably of more or less the same magnitude from year to year. The figures given in Table 11 may therefore be safely taken as a guide to the general trend of the industry.

TABLE 12.—*Quantity and Value of Gold produced in India during 1909 and 1910.*

Province.	1909.		1910.		Average number of persons employed daily.
	Quantity.	Value.	Quantity.	Value.	
	Ounces.	£	Ounces.	£	
Bombay—					
Dharwar	5,616	21,331	737	2,590	337
Burma—					
Myitkyina	8,445	32,730	5,972·24	22,930	176
Katha and Pakokku.	44	135	24·71	119	12(*a*)
Hyderabad	15,241	57,416	15,762·24	59,394	1,851
Jammu and Kashmir.	4	15	236	944(*b*)	Not reported.
Mysore	545,309	2,092,605	547,746	2,105,944	Do.
Madras	..	..	2,532	10,120	1,186
Punjab	154	621	106	432	289
United Provinces	3	13	3·75	13	Not available.
Total	**574,816**	*2,204,866*	**573,119·94**	*2,202,486*	..

(*a*) Exclusive of the figures for Katha, which are not available.
(*b*) Value estimated at £4 per ounce.

Graphite.

There was a marked increase, amounting to nearly 36 per cent. in the outturn of graphite during the year. Most of the mineral won, *viz.*, 3,992 tons, came from the Travancore mines, but a small quantity, 259 tons, is recorded from Vizagapatam; the quality of the latter appears to be poor, its value being stated as £517 or about £2 per ton as against £5 per ton for the Travancore material.

Iron-ore.

There was a very conspicuous drop in the output of iron-ore, which fell from 83,456 tons, valued at £16,563, to 54,626 tons, valued at £9,811. This was due to the reduced outturn in the districts of Burdwan and Manbhum; in the former district there was a decrease in production of nearly 48 per cent., whilst the latter produced no ore at all in 1910.

TABLE 13.—*Production of Iron-ore during the years 1909 and 1910.*

	1909.		1910.	
	Production.	Value.	Production.	Value.
	Tons.	£	Tons.	£
Bengal—				
Burdwan . . .	46,623	6,751	24,387	3,655
Manbhum . . .	10,132	3,389	..	..
Singhbhum . . .	15,215	3,297	17,646	2,703
Other districts . .	741	261	620	260
Bombay	..	..	1	..
Burma	7,480	1,995	7,480	1,995
Central India . . .	484	129	268	72
Central Provinces . . .	1,935	516	3,637	970
Hyderabad	640	171	485	129
Madras	32	8	..	..
Rajputana	157	42	64	17
United Provinces . . .	17	4	38	10
Total .	**83,456**	*16,563*	**54,626**	*9,811*

Jadeite.

As usual, the returns for jadeite exported from Burma are considerably higher than those for actual output at the quarries. The latter figures are undoubtedly the less reliable, since the right to collect royalty is farmed out and it is no doubt to the interest of the licensee to keep the figures as low as possible. The declared output for the year 1910 was only 1,908 cwt., valued at £12,864, as against 2,487 cwt., valued at £14,892, in 1909. The amount exported in 1910 was 2,827 cwt., valued at £64,747, a decrease of 14½ per cent. in quantity and 23 per cent. in value. There is a remarkable difference between the spot values and export values of the material, the latter being just under £23 per cwt. as against £6-15-0 at the mine. The trade would thus appear to be a very profitable one.

Lead-ore.

Burma.

The slags of Bawdwin in the Northern Shan States still continue to yield a large outturn of lead, together with a small amount of silver. A certain amount of lead-ore was won at the same locality. Galena is also produced in small quantities in the Southern Shan States and other parts of Burma, but the Mount Pima venture, on which great hopes had been fixed, proved a disappointment; all the ore in sight was worked out, and the company subsequently went into liquidation.

Table 14 shows the production of ore and bullion for the years 1909 and 1910.

TABLE 14.—*Production of Silver-lead-ore in Burma during 1909 and 1910.*

	1909.			1910.		
	Quantity	Value.		Quantity.	Value.	
	Lead-ore and slag.	Lead-ore and lead.	Silver.	Lead-ore and slag.	Lead-ore and lead.	Silver.
	Tons.	£	£	Tons.	£	£
Mandalay		1·3	..	23	Not known	..
Toungoo	..	..	..	500	1,000	..
Northern Shan States.	(Ore) 458 (Slag) 12,830	(*a*) 73,599·6	(*b*) 2,996 4	(Ore) 975 (Slag) 29,533	2,461 159,081(*c*)	538 4,430(*d*)
Southern Shan States.	90	110·4	..	180	480	..
Yamethin	2,463·5	517	..	..	..	..
Total	**15,843·5**	**74,228·3**	**2,996·4**	**31,211**	**163,022**	**4,968**

(*a*) Value of 5,880 tons of lead extracted.
(*b*) Value of 29,964 oz. of silver extracted.
(*c*) Value of 12,404 tons of lead extracted.
(*d*) Value of 44,300 ounces of silver extracted.

There was a small outturn of 6 tons of lead-ore, valued at £30, from the Drug District of the Central Provinces.

India.

Magnesite.

The magnesite industry of Salem showed signs of recovery during the year, the output rising from 737 tons, valued at £196, in 1909 to 5,182 tons, valued at £1,382, in 1910.

Manganese-ore.

TABLE 15.—*Output of Manganese-ore for the years 1909 and 1910.*

	1909.		1910.	
	Quantity.	Value f. o. b. at Indian ports.	Quantity.	Value f. o. b. at Indian ports.
	Tons.	£	Tons.	£
Bengal—				
Gangpur State . .	55,060	54,142	41,958	41,259
Bombay—				
Panch Mahals . .	17,657	17,363	30,396	31,789
Ratnagiri . . .	..	..	525	424
Central India—				
Jhabua	10,324	7,141	12,664	11,239
Central Provinces—				
Balaghat . . .	134,577	142,427	161,987	182,235
Bhandara . . .	110,856	117,323	159,164	179,059
Chhindwara . . .	17,464	18,483	19,556	22,000
Jubbulpore . . .	..	..	300	197
Nagpur . . .	118,388	125,294	211,232	237,636
Madras—				
Bellary	..	..	500	425
Sandur	78,636	51,769	73,666	62,616
Vizagapatam . . .	59,818	39,380	46,441	39,475
Mysore	39,895	30,586	42,518	41,101
Total .	**642,675**	*603,908*	**800,907**	*849,155*

In *Memoirs, Geological Survey of India*, Vol. XXXVII, and in the Quinquennial Review of the Mineral Production of India for the years 1904-1908 (*Records*, XXXIX, p. 153), the question of the correct method of valuing the Indian output of manganese-ore was discussed in detail, and it was shown that the true value of the industry to India can be best indicated by means of the values of the ore *f. o. b.* at port of export. These values must vary from year to year according to the fluctuations of the world's markets, and it is, therefore, necessary to deduce each year the average price of the respective grades for the whole period. For this purpose, the rates published weekly in the *Mining Journal* have been adopted, and averages have been deduced therefrom. The values so obtained are shown in the following table:—

TABLE 16.—*Prices of Manganese-ore during 1909 and 1910.*

—	1909.	1910.
	d.	*d.*
1st grade ore	9·2	9·5
2nd ,, ,,	8·3	9·3
3rd ,, ,,	None exported.	8·8

The rise in the price of ore during the year under review resulted in a considerable increase in the total production, which rose from 642,675 to s, valued at £603,908 in 1909 to 800,907 tons valued at £849,455, an increase of very nearly 20 per cent. in quantity and of over 40 per cent. in value. The output was somewhat in excess of exports, which are shown in the *Accounts relating to the Sea-borne Trade and Navigation of India* for the year 1910 as 586,577 tons. This figure, however, does not include the exports from Mormugao, which port deals with the Sandur and Mysore manganese; the Mormugao figures have not been received in time for incorporation in this Review, but it is safe to assume that they will lie between 70,000 and 100,000 tons, thus bringing the total exports to over 650,000 tons.

Mica.

There is again an apparent reduction in the output of mica, the figures being 22,699½ cwt. as against 32,903 cwt. for 1909. There was, however, a considerable increase in value which rose from £38,157 in 1909 to £54,427 in the year under review. In spite of the great apparent decrease in production, the exports amounted to 39,612 cwt., valued at £177,152, an increase of 6,609 cwt. over 1909. It is safe to assume, therefore, that the output returns are incomplete.

TABLE 17.—*Production of Mica in 1909 and 1910.*

PROVINCE.	1909.	1910.
	Cwt.	Cwt.
Bengal	22,084	18,356·5
Madras	8,948	3,586
Rajputana	1,871	757
Total .	**32,903**	**22,699·5**

The average number of persons employed daily in the industry during 1910 was 14,073.

Petroleum.

Production.

There was a considerable decrease, amounting to 18,848,440 gallons, or 8 per cent., in the output of petroleum as compared with that of the previous year. The three chief Burmese fields, Yenangyaung, Yenangyat and Singu, all show decreased production. Oil, however, has recently been struck at Minbu and it is hoped that a productive field may be proved in that neighbourhood.

TABLE 18.—*Production of Petroleum during 1909 and 1910.*

	1909.	1910.
	Gallons.	Gallons.
Burma—		
Akyab	24,758	22,258
Kyaukphyu	39,064	33,544
Magwe (Yenangyaung)	187,043,800	174,967,298
Myingyan (Singu)	37,169,061	31,524,175
Pakokku (Yenangyat)	6,119,934	4,942,308
Minbu	*Nil.*	18,320
Eastern Bengal and Assam—		
Digboi	3,280,750	3,320,680
Punjab	720	1,064
Total .	**233,678,087**	**214,829,647**

Exports.

The exports of petroleum rose from 2,265,649 gallons in 1909 to 2,828,857 gallons in 1910, but this figure is still less than half of that for the year 1908; the value, however, was £46,700, which is £8,396 better than that for 1908. This is due to the increased export of petrol. The exports of paraffin wax have very nearly trebled during the past three years, having risen from 83,572 cwt. in 1908 to 230,718 cwt. valued at £353,514 in 1910.

Imports.

Imports of kerosene continued to show a reduction, and fell from 70,514,379 gallons in 1909 to 57,359,905 gallons in the year under review.

TABLE 19.—*Imports of Kerosene Oil during 1909 and 1910.*

Country of origin.	1909.	1910.
	Gallons.	Gallons.
Borneo	6,970,796	7,070,006
Roumania	3,919,632	..
Russia	7,207,322	1,196,700
Straits Settlements	7,610.705	4,395,296
Sumatra	5,258,404	5,560,500
United States of America	39,547,072	39,112,982
Other countries	348	24,421
Total	**70,514,379**	**57,359,905**

Labour.

The average daily number of labourers working on the oil-fields during 1909 was returned as 5,816.

Ruby, Sapphire and Spinel.

The output of the Mogok mines during the year amounted to 262,019 carats valued at £58,849, an increase on the previous year of 4,715 carats in weight, but only £200 in value. The average attendance of labour was 1,463 persons per diem.

Salt.

There was a considerable increase—amounting to nearly 24 per cent.—in the production of salt during the year. Table 20 shows the provincial outturn and Table 21 that of rock-salt in Northern India. The imports of foreign salt decreased slightly, being 496,165 tons against 525,374 tons in the year 1909.

TABLE 20.—*Provincial Production of Salt for the years 1909 and 1910.*

PROVINCE.	1909.	1910.
	Tons.	Tons.
Aden	66,535	67,347
Bengal	34	22
Bombay and Sind	443,707	483,322
Burma	26,944	22,692
Gwalior State	183	52
Madras	309,583	464,607
Northern India	408,612	514,917
Kashmir	..	16
Total .	**1,255,598**	**1,552,975**

TABLE 21.—*Production of Rock-salt during 1909 and 1910.*

Mines.	1909.	1910.
	Tons.	Tons.
Salt Range	126,987	119,868
Kohat	15,875	17,098
Mandi State	3,857	3,671
Total .	**146,719**	**140,637**

Saltpetre.

An interesting account of the saltpetre industry, by Dr. J. W. Leather and Babu Jatindra Nath Mukerji, has recently been published as *Bulletin No. 24* of the Agricultural Research Institute, Pusa. Detailed descriptions are given in this of the existing processes and valuable suggestions made as to possible improvements in methods of refining.

Production.

It has not been possible in previous years to obtain reliable statistics as to the production of saltpetre in India, and only export figures have been employed hitherto to indicate the progress of the industry. An attempt, however, has now been made to collect statistics from the respective provinces, and the annexed table (Table 22) embodies the returns received. From this it would appear that the total production during the year was 15,541 tons, valued at £223,762; the amount exported was 15,398 tons. Table 23 shows the destination of these exports.

TABLE 22.—*Production of Saltpetre during 1910.*

—	1910.	
	Quantity.	Value.
	Tons.	£
North-West Frontier Province	22	481
Punjab	3,481	55,034
United Provinces of Agra and Oudh . . .	5,225	72,987
Behar	6,772	92,099
Central India	23	176
Rajputana	18	2,985
Total .	**15,541**	**223,762**

TABLE 23.—*Distribution of Saltpetre exported during 1909 and 1910.*

—	1909.		1910.	
	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£
China	133,382	92,735	79,673	58,062
France	28,530	19,624	3,325	2,543
United Kingdom . . .	81,503	57,321	58,105	43,890
United States of America .	84,096	73,296	88,506	73,593
Other Countries . . .	77,435	53,862	78,353	52,527
Total .	**404,946**	*296,838*	**307,962**	*230,615*

Tin-ore.

The propriety of retaining tin-ore amongst the minerals for which approximately full returns are available, is doubtful. Practically the whole output is derived from Burma, where the industry is carried on by a number of small holders working on primitive

Production.

lines and under conditions which render it practically impossible to obtain any reliable figures as to the total output of ore, which is deduced merely from records of the quantity passed through the customs stations. The figures consequently afford only an index as to the amount exported, whilst a further complication is introduced by the export also of block tin, produced from local furnaces. Considerable uncertainty is introduced into the figures by the absence of information as to the exact degree of concentration of the ore smelted locally; experience, however, shows that this is approximately 70 per cent., and this figure may be adopted as being correct within comparatively small limits of error. The total outturn of ore from Mergui, as locally recorded, was 1,767½ cwt., of which 667½ cwt. were exported. The remainder, 1,100 cwt., was presumably smelted and formed part of the raw material from which the 1,507 cwt. of block tin exported were derived. If we adopt 70 per cent. as the concentration-value of the ore, 1,507 cwt. of block tin would be obtained from 2,153 cwt. of ore; hence it would appear that the returns fall short by about 1,053 cwt. of the amount actually won. It is, of course, possible that this amount may represent stocks held over from previous years, but the whole industry is too small to make this supposition a probable one.

The total outturn of tin-ore and block tin is shown in Table 24, from which it will be seen that the value has increased from £9,645 in 1909 to £18,578 in 1910, an increase of 92 per cent.

TABLE 24.—*Production of Tin-ore and Tin for the years 1909 and 1910.*

PROVINCE.	1909.		1910.			
	TIN-ORE.		BLOCK TIN.		TIN-ORE.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£	Cwt.	£
Bengal—						
Hazaribagh	..	..	..	..	3	26
Burma—						
Mergui .	1,665	9,611	1,507	10,935	1,767½	7,589
Tavoy .	7	34	..	..	6	28
Total .	**1,672**	*9,645*	**1,507**	*10,935*	**1,776½**	*7,648*

Imports.

The imports of block tin in 1910 amounted to 38,687 cwt., valued at £301,955, as against 34,477 cwt., valued at £283,899 in the previous year.

Tungsten-ore.

Wolfram.

During the investigations carried out by the Geological Survey a few years ago with respect to the tin industry in Lower Burma, Mr. J. J. A. Page found that wolframite was not uncommon in the schists and granite of Tavoy, and also occurred as pebbles in the alluvial deposits derived from those rocks. Attention having thus been drawn to these deposits, considerable activity has recently been shown by prospectors and others in testing the possibilities of Mergui and Tavoy as sources of wolfram. This activity is reflected in the outturn of ore (wolframite), amounting to 362 tons in Tavoy during the year 1910. A small quantity, 33 tons, was also won at Mawchi in the Southern Shan States, whilst the Agargaon deposit in Nagpur District yielded only 18 cwt. The total output of India and Burma thus amounted to 396 tons, valued at £38,873.

As the industry will probably be to a great extent in the hands of European companies, fairly reliable returns will probably be obtainable, and tungsten has, therefore, now been transferred to Group I.

III.—MINERALS OF GROUP II.

Alum.

The output of alum in Mianwali District, Punjab, increased from 4,629 cwt., valued at £1,995, in 1909 to 6,220 cwt., valued at £2,869, in the year under review. An account of the industry was recently published in these *Records* (Vol. XXXVIII, pt. 3), and there is no doubt that with improved methods, the industry might be widely extended. The amount of suitable raw material in the carbonaceous shales of the coal-measures of Dandot and Pidh in the eastern Salt Range is large and easily obtainable. The demand for alum in India is very considerable, the imports during the year 1910 having amounted to 69,588 cwt., valued at £21,466. The distance of the Salt Range from the chief commercial centres is, however, no doubt a deterrent factor in the development of the indigenous industry.

Amber. There was a small increase in the output of amber from Myitkyina in Upper Burma, 63 cwt., valued at £283, being obtained, as against 31 cwt. in the previous year. The total value, however, is said to be £4 less than that of the much smaller quantity won in 1909.

Asbestos. There was a small output of 3 tons of asbestos, valued at £6 from Bhandara District, Central Provinces. This was presumably only a sample raised in the course of prospecting operations.

Bauxite. The extensive deposits of Indian bauxite still remain undeveloped, but the Katni quarries again produced a small quantity, 66 tons, valued at £25.

Borax. Although borax is not produced in India, but in Tibet, most of the output probably comes to this country for export and distribution, and it may, therefore, be suitably dealt with in this review. The amount exported during 1910 rose to 6,272 cwt., valued at £7,356, an increase of nearly 24 per cent.

Building materials. The returns for building materials are still too incomplete to be included in Group I, but the annual value is considerable, ranging, as it does, from about a quarter to a little over half a million sterling. The approximate output of the respective provinces is shown in Table 25. The value is only £222,400 as against £563,415 for 1909. The decrease is largely due to the cessation of the output of granite in the Thaton District of Burma, an item which brought the value of the output of that rock and gneiss up to nearly £470,000 in 1909.

Clay. The returns for clay for the year 1910 are very much more complete than any hitherto received, and show a total output of 843,736 tons, valued at £59,160. By far the greater proportion of this figure consists of the outputs in Burma and Madras, which are returned as 490,063 and 314916 tons respectively, whereas Bengal shows only 22,832 tons, and the Central Provinces 15,836 tons. If it were possible to obtain returns for the other provinces as full as are those for Madras and Burma, the value of the industries—chiefly brick-making and the manufacture of unglazed pottery—dependent on this raw product, would form an appreciable item in the total value of the mineral production. The difficulties of collecting complete

TABLE 25.—*Production of Building materials and Road metal in India during 1910.*

	NATURE OF MATERIAL.																	
	GRANITE.		LATERITE.		LIME.		LIMESTONE AND KANKAR.		MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£	Tons.	£
Baluchistan	...	...	...	..	..		481	449	..	..		..	..	.	..	..	...	..
Bengal	3,235	220	14,901	1,963	...		37,768	17,769	.	..	82,996	12,482	1,300	1,362	43,901	1,303	145,950	9,535
Bombay	...	..	...	...			300	100	.	...						...	.	...
Burma	145,728	18,481	251,383	20,743		..	232,960	15,308	.	..	97,096	7,564	153	82	14,464	1,152	101,380	5,172
Central India	.	...	...	.	26,410	14,013	32,745	2,603*		..	...		.	..		...	864	23
Central Provinces	...	...	.			.	80,985	4,731		.	.		...	.	...	...	...	..
Eastern Bengal and Assam.	...	...	.	.	...		123,110	10,866	..	...	.	..		.		..	.	..
Hyderabad	...	...	...	...	...		Not reported.	1	.		Not reported.	11		...	..	..	Not reported.	1,369
Madras	98,997	4,581	592,586	4,382	...		628,158	25,840			234,000	1,920		..	..	.	225,544	6,955
Punjab	...		...		...		18,894	Not reported.	.			.	9,539	10,046	..	..	6,394	100
Rajputana	..	...	..		.		13,259		2,199	1,127	262	30	13,211	Not reported.		...	...	...
United Provinces	...	...	...	...	67	69	89	10	.	..	181,543	20,129	5	9	...	...	...	.
TOTAL	247,960	23,282	858,820	26,988	26,477	14,082	1,168,749	77,677	2,199	1,127	595,897	42,136	24,208	11,499	58,365	2,455	480,132	23,154

* Represents the value of 30,620 Tons only.

and accurate figures are, however, so great that it is doubtful if the information gained could be fairly regarded as commensurate with the labour involved in its acquisition.

Copper.

In the course of the next few years, it is to be hoped that copper will take an important place among the minerals of Group I. At present, the industry is still in the prospecting stage, both in Sikkim and in Singhbhum, although an output of 864 tons of ore, valued at £2,304, has been reported from the latter district. Two hundred and ninety tons of ore, valued at £579, were also won in the Myitkyina District in Upper Burma, and 2 tons, valued at £4, in Garhwal (United Provinces).

Corundum.

The total production of corundum during the year was 2,741 cwt. valued at £634. Of this, 1,055 cwt. were produced in Rewa and 1,686 cwt. in Madras. The output returned in 1909 was only a little over 280 cwt., almost all of which came from Rewa.

Garnet.

The only returns received for production of garnet are from Rajputana, where 318 cwt., valued at £1,842, were produced in Kishengarh, and 1½ cwt., valued at £43, in Ajmere. This constitutes a decrease of nearly 20 per cent. in quantity and 35 per cent. in value on the outturn in 1909. The average daily attendance of labourers was 165.

Gypsum.

The Jamsar gypsum deposits in Bikanir produced 4,286 tons, valued at £160. There was also an output of 450 tons valued at £123 from the Delhi District of the Punjab and 1,837 tons from the Jhelum District.

Ochre.

The total production of ochre during 1910 is returned as 1,020 tons, valued at £64, of which 815 tons were derived from Panna State in Central India and 198 tons from the Drug District of the Central Provinces.

Steatite.

Table 26 shows the output of steatite during the year. The total production was 4,897 cwt., valued at £1,106 ; this is less than half, in quantity, of the production of the Jubbulpore quarry alone in 1909 ; the output of this quarry was only 3,068 cwt. in 1910 as against 11,296 cwt. in the previous year. The Burmese production has also fallen by nearly 100 cwt. ; most of the output comes from the mines on the Arakan Yoma and near Hpa-aing in the Minbu District.

TABLE 26.—*Production of Steatite during 1909 and 1910.*

—	1909.		1910.	
	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt	£
Burma—				
Minbu	280	420	260	656
Pakokku . . .	80	57	9	7
Central Provinces—				
Jubbulpore . . .	11,296	769	3,068	209
Madras—				
Karnul . . .	.	..	400	80
Nellore	..	..	160	21
United Provinces—				
Jhansi		..	1,000	133
Total .	**11,656**	**1,246**	**4,897**	**1,106**

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 27.—*Statement of Mineral Concessions granted during 1910.*

BALUCHISTAN.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kalat	(1) Khan Bahadur Burjorjee D. Patel, C.I.E.	Coal	M. L.	213	1st July 1910	30 years.
Quetta	(2) Mr. W. C. Clements	Chromite	M. L.	80	1st January 1910.	Do.
Do.	(3) Messrs. Tahil Mal Teck Chand & Co.	Coal	P. L.	432	19th March 1910.	1 year.
Sibi	(4) Mr. W. C. Clements	Do.	M. L.	160	1st July 1910	30 years.
Zhob	(5) Do. do.	Chromite	M. L.	160	1st January 1910.	Do.
Do.	(6) Do. do.	Do.	M. L.	80	Do.	Do.
Do.	(7) Do do.	Do.	M. L.	80	Do.	Do.
Do.	(8) Do. do.	Do.	M. L.	185	Do.	Do.
Do.	(9) Do. do.	Do.	M. L.	80	Do.	Do.

BENGAL.

Hazaribagh	(10) Mr. W. D. Clyburn	Mica	M. L.	80	3rd January 1910.	30 years.
Do.	(11) Babu Hurnath Singh	Do.	M.L.	40	11th July 1903.	Do.
Do.	(12) Do. do.	Do.	M. L.	425	1st November 1903.	Do.
Do.	(13) Babu Raghubir Roy	Do.	M. L.	40	12th June 1903.	Do.
Do.	(14) Do. do.	Do.	M. L.	40	5th May 1905	Do.
Do.	(15) Do. do.	Do.	M. L.	40	19th March 1908.	Do.
Do.	(16) Babu Akhoy Kumar Gupta.	Do.	M. L.	200	15th November 1903.	Do.
Do.	(17) Do. do.	Do.	M. L.	224	Do.	Do
Do.	(18) Do. do.	Do.	M L.	80	5th May 1905	Do.
Do.	(19) Do. do.	Do.	M. L.	40	21st November 1905.	Do.
Do.	(20) Do. do.	Do.	M. L.	6·38	2nd November 1908.	Do.
Do.	(21) Do. do.	Do.	M. L.	20	10th November 1908.	Do.

E. L. denotes Exploring License, P.L., Prospecting License, and M. L., Mining Lease.

BENGAL—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh .	(22) Messrs. Martin & Co.	Mica. . .	M. L. .	40	1st December 1903.	30 years.
Do. .	(23) Do. do. .	Do. . . .	M. L. .	145	Do. .	Do.
Do. .	(24) Do. do. .	Do. . . .	M. L. .	263	15th February 1904.	Do.
Do. .	(25) Messrs. Gladstone, Wyllie & Co.	Do. . . .	M. L. .	360	5th May 1905	Do.
Do. .	(26) Do. do. .	Do. . . .	M. L. .	80	28th September 1905.	Do.
Do. .	(27) Do. do. .	Do. . . .	M. L. .			
Do. .	(28) Do. do. .	Do. . .	M. L. .	160	27th October 1905.	Do.
Do. .	(29) Do. do. .	Do . . .	M. L. .	205	25th November 1905.	Do.
Do. .	(30) Do. do. .	Do. . . .	M. L. .	80	12th April 1906.	Do.
Do. .	(31) Do. do. .	Do. . . .	M. L. .	200	11th May 1907.	Do.
Do. .	(32) Do. do.	Do. . . .	M. L. .	550	3rd April 1908	Do.
Do. .	(33) Mica Supply and Company.	Do. . . .	M. L. .	360	21st November 1905.	Do.
Do. .	(34) Do. do. .	Do. . . .	M. L. .			
Do. .	(35) Mr. K. E. Heneymann.	Do. . . .	M. L. .	360	Do. .	Do.
Do. .	(36) Do. do. .	Do. . . .	M. L.			
Do. .	(37) Do. do. .	Do. . . .	M. L. .	40	Do. .	Do.
Do. .	(38) Do. do. .	Do. . . .	M. L. .	123·88	5th May 1905	Do.
Do. .	(39) Babu Satyapado Sirkar.	Do. . . .	P. L. .	232·50	31st May 1910	1 year.
Do. .	(40) Babu Ram Ratan Ram.	Do. . . .	P. L. .	122·5	14th June 1910.	Do.
Do. .	(41) Mr. J. W. Martin .	Do. . . .	P. L. .	320	11th July 1910	Do.
Do. .	(42) Messrs. Gladstone, Wyllie & Co. . .	Do. . . .	P. L. .	120	9th July 1910	Do.
Do. .	(43) Babu Akhoy Kumar Gupta.	Do. . . .	P. L. .	21·60	2nd August 1910.	Do.
Do. .	(44) Babu Bogola Prosanna Majumdar.	Do. . . .	P. L. .	240	30th August 1910.	Do.
Do. .	(45) Mr. C. Murray .	Do. . . .	P. L. .	71·70	10th September 1910.	Do.
Do. .	(46) Mr. H. A. Pearson .	Do. . . .	P. L. .	280	Do. .	Do.
Do. .	(47) Mr. S. D. Philippe .	Do. . .	P. L. .	40	11th February 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BENGAL—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Hazaribagh .	(48) Babu Raj Krishna Sahana.	Mica . . .	M. L. .	460	1st November 1903.	30 years.
Do. .	(49) Do. do. .	Do. . . .	M. L. .	800	11th September 1903.	Do.
Do. .	(50) Do. do. .	Do. . . .	M. L. .	46	27th March 1905.	Do.
Do. .	(51) Do. do. .	Do. . . .	M. L. .			
Do. .	(52) Do. do. .	Do. . . .	M. L. .			
Do. .	(53) Bengal Mica Syndicate, Limited.	Do. . . .	M. L. .	280	5th May 1905	Do.
Do. .	(54) Do. do. .	Do. . . .	M. L. .	544¼	1st November 1903.	Do.
Do. .	(55) Do. do. .	Do. . . .	M. L. .	583	14th September 1903.	Do.
Do. .	(56) Do. do. .	Do. . . .	M. L. .	200	1st April 1905	Do.
Do. .	(57) Mr. Shivji Walji .	Do. . . .	P. L. .	280	14th December 1910.	1 year.
Do.	(58) Babu Akhoy Kumar Gupta.	Do. . . .	P. L. .	9·77	26th November 1910.	Do.
Do. .	(59) Mr. A. A. C. Dickson.	Do. . . .	P. L. .	280	14th December 1910.	Do.
Do. .	(60) Babu Monoranjan Guha.	Do. . . .	M. L. .	40	1st November 1903.	30 years.
Do. .	(61) Do. do. .	Do. . . .	M. L. .	120	Do.	Do.
Do. .	(62) Do. do. .	Do. . . .	M. L. .	80	1st February 1904.	Do.
Do. .	(63) Do. do. .	Do. . . .	M. L. .	80	5th May 1905.	Do.
Do. .	(64) Do. do. .	Do. . . .	M. L. .	160	21st November 1905.	Do.
Do. .	(65) Do. do. .	Do. . . .	M. L. .	120	8th April 1905	Do.
Do. .	(66) Mr. A. A. C. Dickson	Do. . . .	P. L. .	80	26th November 1910.	1 year.
Puri . .	(67) Miss Florentia W. Harrison, M.D.	Lead and its oxides.	P. L. .	640	1st February 1911.	Do.
Sambalpur .	(68) Mineral Syndicate of Bombay.	Coal . . .	M. L. .	3155·2	1st September 1909.	30 years.
Do. .	(69) The Hingir-Rampur Coal Company, Ltd., Bombay.	Do. . . .	P. L. .	1123·52	25th May 1910.	1 year.
Do. .	(70) Lala Ganesh Prasad, Janki Prasad and Brothers, Mining Proprietors, Kamptee, Central Provinces.	Mica and steam coal.	P. L. .	230·20	4th July 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BENGAL—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Sambalpur .	(71) J. Saubolle . .	Minerals of every description.	E. L. .	The district of Sambalpur excluding 1832·17 acres of land.	2nd August 1910.	1 year.
Singhbhum .	(72) The Bengal Iron and Steel Co., Ltd., 6 and 7, Clive Street, Calcutta.	Iron-ore . .	M. L. .	3,840	30th March 1910.	2 years.
Do. .	(73) Do. do. .	Do. . .	M. L. .	3,200	6th February 1910.	Do.
Do. .	(74) Messrs. Schroder, Smidt & Co. of Calcutta.	Manganese . .	P. L. .	704	25th April 1910.	1 year.
Do. .	(75) Do. do. .	Do. . .	P. L. .	1,088	Do. .	Do.
Do. .	(76) Do. do. .	Do. . .	P. L. .	2,048	Do. .	Do.
Do. .	(77) Do. do. .	Do. . .	P. L. .	1,024	Do. .	Do.
Do. .	(78) Do. do. .	Do. . .	P. L. .	1,472	Do. .	Do.
Do. .	(79) Mr. J. A. Joseph of Calcutta.	Do. . .	P. L. .	576	13th June 1910.	Do.
Do. .	(80) Do. do. .	Do. . .	P. L. .	896	Do. . .	Do.
Do. .	(81) Do. do. .	Do. . .	P. L. .	960	Do. . .	Do.
Do. .	(82) The Bengal Iron and Steel Co., Ltd., 6 and 7, Clive Street, Calcutta.	Iron-ore . .	M. L. .	249·60	6th December 1909.	30 years.
Do. .	(83) Mr. P. N. Bose of Ranchi.	Gold . . .	P. L. .	2,160	7th October 1910.	1 year.
Do. .	(84) Mr. J. A. Joseph of Calcutta.	Manganese .	P. L. .	1,299·2	5th November 1910.	Do.

BOMBAY.

Karachi .	(85) Mr. S. H. Cunningham Craig, on behalf of the Burmah Oil Co., Ltd.	Mineral oils .	E. L. .	337,280	21st March 1910.	1 year.
Panch Mahals	(86) Messrs. Shaw, Wallace & Co.	Manganese . .	M. L. .	115	22nd March 1910.	10 years.
Do. .	(87) Mr. Ratanlal Ranchhoddas.	Do. . .	E. L. .	46	July 1908 . (Exact date not reported by the Collector.)	1 year.
Do. .	(88) Messrs. Shaw, Wallace & Co.	Do. . .	M. L. .	524	22nd March 1910.	10 years.
Ratnagiri .	(89) Messrs. Nansee Khairaz & Co.	Do. . .	M. L. .	12	1st January 1909.	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab	(90) Messrs. Mower & Co.	Petroleum	P. L.	2,560	26th March 1910.	1 year.
Do.	(91) Mr. W. Mansfield	Do.	M. L.	568·91	1st January 1910.	30 years.
Do.	(92) The Rangoon Refinery Co., Ltd.	Do.	P. L.	6,720	28th October 1910.	1 year.
Do.	(93) Hon'ble Babu Bhupendra Nath Basu.	Do.	P. L.	1,600	30th September 1910.	Do.
Amherst	(94) Mr. S. Crawshaw	All minerals	E. L.	All un-occupied areas in the district excluding Reserve Forests.	17th March 1910.	Do.
Do.	(95) Yeo Eng Byan	Silver and gold	P. L.	620·73	30th April 1910.	Do.
Do.	(96) Colonel S. G. Radcliff.	Gold, silver, tin, copper, lead and antimony.	P. L.	7,398	14th December 1910.	Do.
Henzada	(97) Mr. F. L. Phipps	Petroleum	P. L. (renewal).	1,920	4th March 1910.	Do.
Do.	(98) Messrs. Tucker & Co.	Coal	P. L.	3,002·88	10th May 1910.	Do.
Do.	(99) Messrs. Martin & Co.	Petroleum	P. L.	7,914	4th August 1910.	Do.
Katha	(100) Messrs. Mower & Co.	Gold	P. L.	1,600	24th August 1910.	Do.
Do.	(101) C. Soon Thin	Lead	P. L	2,464	2nd September 1910	Do.
Do.	(102) Hlethin Atwinwunmin.	Gold lead and copper.	E. L.	Within the jurisdiction of Shwe-Chaung, Lonkin, Legyin and Pinsindi Headmen.	6th October 1910.	Do.
Magwe	(103) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Petroleum	P. L.	2,240	19th February 1910.	Do.
Do.	(104) Indo-Burma Petroleum Company.	Do.	P. L.	1,280	9th March 1910.	Do.
Do.	(105) Mr. W. Mansfield	Do.	P. L.	2,560	20th June 1910.	Do.
Do.	(106) Maung Kyaw E.	Do.	P. L. (renewal).	180·03	20th October 1909.	Do.
Do.	(107) Maung Maung Gyi	Do.	P. L. (renewal).	383	29th March 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Magwe . .	(108) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Petroleum . .	P. L. (renewal).	1,280	28th April 1910.	1 year
Do. . .	(109) Do. do. .	Do. . .	P. L. .	2,560	1st August 1910.	Do.
Do. . .	(110) Do. do. .	Do. . .	P. L. (renewal).	7,680	1st May 1910	Do.
Do. . .	(111) Sulaiman Adamji .	Do. . .	P. L. .	960	29th September 1910.	Do.
Do. . .	(112) Do. do. .	Do. . .	P. L. (renewal).	Blocks 55 and 65.	4th June 1910.	Do.
Do. . .	(113) Maung Tun Aung Gyaw.	All kinds of minerals.	E. L. .	6,400	29th September 1910.	Do.
Do. . .	(114) Maung Lu Gale .	All minerals (except oil).	E. L. .	12,800	29th September 1910.	Do.
Do. . .	(115) Messrs. The Nath Singh Oil Company, Ltd.	Petroleum . .	P. L. .	15,360	7th October 1910.	Do.
Mandalay .	(116) Messrs. W. Macdonald and W. A. Battle.	Galena, gold, silver, and copper.	P. L. .	320	3rd May 1910	Do.
Do. .	(117) Mr. W. Macdonald	Lead, copper, silver, gold and iron.	P. L. .	560	27th August 1910.	Do.
Do. .	(118) Do. do. .	Do. . .	P. L. .	1,920	Do. .	Do.
Do. .	(119) Mr. Z. M. D'Silva	Minerals of all descriptions (except oil).	E. L. .	5,248	2nd September 1910.	Do.
Do. .	(120) Messrs. Mower & Co.	Silver, lead, zinc and copper.	P. L. (renewal).	1,280	13th December 1910.	Do.
Meiktila .	(121) Colonel S. G. Radcliff.	Lead and copper .	P. L. .	1,280	1st July 1910	Do.
Do. .	(122) Do. do. .	Do. . .	P. L. .	1,280	Do. .	Do.
Mergui . .	(123) Mr. Charles Kitchin	Tin . . .	P. L. .	640	4th February 1910.	Do.
Do. . .	(124) Mr. A. B. Snow, on behalf of Burma Development Syndicate.	Tin and wolfram .	P. L. .	960	12th February 1910.	Do.
Do. . .	(125) Mr. B. A. Baldwin on behalf of Messrs. Mower & Co.	Tin and its associated minerals.	P. L. .	2,240	23rd April 1910.	Do.
Do. . .	(126) Do. do. .	Do. . .	P. L. .	2,560	Do. .	Do.
Do. . .	(127) Do. do. .	Do. . .	P. L. .	80	Do. .	Do.
Do. . .	(128) Mr. C. W. Chater .	All minerals .	P. L. .	3,200	5th March 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui . .	(129) Mr. B. A. Baldwin on behalf of Messrs. Mower & Co.	Tin and its associated metals.	P. L. .	3,200	5th March 1910.	1 year.
Do. .	(130) Mr. C. W. Chater .	All minerals .	P. L. .	3,200	23rd May 1910.	Do.
Do. .	(131) Messrs. Diekmann Brothers & Co., Ltd.	Gold, tin and other minerals.	P. L. .	3,200	3rd June 1910.	Do.
Do. .	(132) Mr. B. A. Baldwin on behalf of Messrs. Mower & Co.	Tin and associated minerals.	P. L. .	3,200	30th August 1910.	Do.
Do. .	(133) Messrs. Mower & Co.	Do. . .	P. L. .	1,920	Do. .	Do.
Do. .	(134) Do. do. .	Do. . .	P. L. .	3,200	13th July 1910.	Do.
Do. .	(135) Mr. Chia Boon Taik	Tin and wolfram .	E. L. .	Throughout Mergui District.	30th July 1910.	Do.
Do. .	(136) Do. do. .	Do. . .	P. L. .	3,200	8th July 1910	Do.
Do. .	(137) Mr. T. B. Kantharia	Manganese . .	P. L .	3,200	15th September 1910.	Do.
Do. .	(138) Mr. A. E. Laudon White.	Coal . . .	P. L. (renewal).	2,611·2	1st August 1910.	Do.
Do. .	(139) Mr. Kitchen .	Tin, wolfram and copper.	P. L. .	320	30th September 1910.	Do
Do. .	(140) Maung Mya .	Tin, wolfram and other associated minerals.	E. L. .	Throughout Mergui District.	8th November 1910.	Do.
Do. .	(141) Sit Shoo and Oo Ghine.	All minerals .	P. L. .	1,920	6th December 1910.	Do.
Do. .	(142) E. Ahmed . .	Wolfram, tin, gold and allied metals.	P. L. .	3,200	13th December 1910.	Do.
Do. .	(143) Maung Shwe Yeik.	Copper, wolfram and antimony.	P. L. .	3,200	25th November 1910.	Do.
Minbu . .	(144) Maung Saing .	Petroleum . .	P. L. .	78·59	2nd March 1910.	Do.
Do. .	(145) Sulaiman Adamjee	Do. . .	P. L. .	3,995·52	20th January 1910.	Do.
Do. .	(146) Shamuddin . .	Do. . .	P. L. .	661·58	1st March 1910.	Do.
Do. .	(147) Do. .	All kinds of minerals.	E. L. .	The whole of the Sidoktaya township.	15th January 1910.	Do.
Do. .	(148) Mr. J. Lister James for Burmah Oil Co., Ltd.	Petroleum . .	P. L. .	960	1st May 1910	Do.
Do. .	(149) Sulaiman Adamjee	Do. . .	P. L. .	2,529	1st March 1910.	Do.
Do. .	(150) Do. do. .	Do. . .	P. L. .	1,920	1st October 1909.	Do.

E. L. denotes Exploring Licence, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Minbu	(151) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Petroleum	P. L.	1,600	1st January 1910.	1 year.
Do.	(152) Do. do.	Do.	P. L. (renewal).	2,880	1st April 1910	Do.
Do.	(153) The Nath Singh Oil Co., Ltd.	Do.	P. L.	1,280	15th July 1910	Do.
Do.	(154) Moolla Dawood Sons & Co.	Do.	E. L.	960	13th August 1910.	Do.
Do.	(155) British Borneo and Burma Petroleum Syndicate.	Do.	E. L.	39,680	8th September 1910.	Do.
Do.	(156) Maung Wa Byaw	All minerals	E. L.	241,280	17th October 1910.	Do.
Myingyan	(157) Ma Kyi Kyi	Mica and other minerals.	E. L.	Over Sale Township (except areas over which mining leases or prospecting licenses have been issued and the Gwegyo Forest reserve.)	28th January 1910.	Do.
Do.	(158) Mr. W. Mansfield	Petroleum	P. L.	1,920	10th February 1910.	Do.
Do.	(159) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Do.	M. L.	134·40	19th January 1909.	30 years.
Do.	(160) Moola Ahmed	Do.	P. L.	640	5th May 1910	1 year.
Do.	(161) Mr. H. W. Watts	Do.	P. L.	82·28	3rd June 1910	Do.
Do.	(162) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Do.	P. L.	1,320	10th May 1910.	Do.
Do.	(163) Mr. R. R. Macdonald.	Do.	P. L.	94·83	20th June 1910.	Do.
Do.	(164) Mr. J. Wilson	Do.	P. L.	3,920	11th August 1910.	Do.
Do.	(165) Maung Maung Pe	Do.	P. L.	4,160	26th August 1910.	Do.
Do.	(166) Do. do.	Do.	P. L.	640	29th August 1910.	Do.
Do.	(167) Sulaiman Adamji	Do.	P. L.	1,280	18th August 1910.	Do.
Do.	(168) Do. do.	Do.	P. L.	640	Do.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan	(169) Moolla Ahmed .	Petroleum . .	P. L. (renewal).	1,280	22nd August 1910.	1 year.
Do. .	(170) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Do. . .	P. L. (renewal).	7,680	1st May 1910.	Do.
Do. .	(171) Messrs. The Nath Singh Oil Co., Ltd.	Do. . .	P L. .	5,760	11th October 1910.	Do.
Do. .	(172) Maung Aung Ba .	Do. . .	P. L. .	903·68	12th October 1910.	Do.
Do. .	(173) Messrs. The Nath Singh Oil Co., Ltd.	Do. . .	P. L. .	2,560	29th October 1910.	Do.
Do. .	(174) Maung Than Zin .	Do. . .	P. L. .	2,560	13th October 1910.	Do.
Northern Shan States.	(175) Mr. W. R. Hillier .	Lead and allied ores.	E. L. .	960	2nd February 1910.	Do.
Do. .	(176) Do. do. .	Lead and allied minerals.	P. L. .	960	26th February 1910.	Do.
Do. .	(177) Saw Hke . .	Gold and allied metals.	P. L. .	5,120	25th July 1910.	Do.
Do. .	(178) Mr. A. R. Oberlander.	Silver, lead, iron and copper.	P. L. .	3,200	4th November 1910.	Do.
Pakokku .	(179) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Petroleum . .	M. L. .	Block No. 134 in Yenangyat Oil-field.	3rd January 1909.	30 years.
Do. .	(180) Mr. G. E. Hayes .	Petroleum and other minerals.	E. L. .	640	19th February 1910.	1 year.
Do. .	(181) Mr. W. Mansfield .	Petroleum . .	P. L. .	Blocks Nos. 119, 121, 122 and 137.	11th March 1910.	Do.
Do. .	(182) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co , Ltd.	Do. . .	M. L .	Blocks Nos. 61, 66 and 71 at Yenangyat.	10th October 1909.	30 years
Do. .	(183) Mr. J. W. Parry .	Do. .	E. L. .	640	23rd March 1910.	1 year.
Do. .	(184) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Do. . .	P. L. (renewal).	Block No. 138 in Yenangyat Oil-field.	10th May 1910.	Do.
Do. .	(185) Mr. J. W. Parry .	Do. .	E. L. (renewal).	Undemarcated blocks Nos. 65 and 72 and 1,280 acres north of block No. 137 in the Yenangyat Oil-field.	23rd March 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Pakokku .	(186) Mr. J. W. Parry.	Petroleum . .	E. L. (renewal).	Demarcated Blocks Nos. 65 and 72 in the Yenangyat Oil-field.	23rd March 1910.	1 year.
Do. .	(187) Messrs. Mower & Co., Agents for the Rangoon Oil Co., Ltd.	Do. . .	P. L. (renewal).	Block No. 124 in Yenangyat Oil-field.	26th April 1910.	Do.
Do. .	(188) Mr. G. E. Hayes, Agent for Myaing Petroleum Syndicate.	Do. . .	E. L. .	7,680	9th June 1910	Do.
Do. .	(189) Messrs. Mower & Co., Agents for the Rangoon Oil Co., Ltd.	Do. . .	M. L. .	Block No. 133 at Yenangyat,	7th January 1910.	30 years.
Do. .	(190) Maung Kyaw Zan .	Do. . .	E. L. .	1,280	10th October 1910.	1 year.
Prome . .	(191) Mr. W. B. E. Rule.	Do. . .	P. L. (renewal).	10,496	5th June 1910	Do.
Ruby Mines .	(192) Maung Yin Gyin .	Tourmaline .	E. L. .	4,000	1st June 1910	Do.
Do. .	(193) Maung Kyi Nyo .	Rubies . .	E. L. .	1,280	1st August 1910.	Do.
Do. .	(194) Maung Kin . .	Corundum . .	E. L. .	4,045	27th October 1910.	Do.
Salween. .	(195) Mr. Rowland Ady .	Galena . .	P. L. .	2,560	1st May 1910	Do.
Do. . .	(196) Mr. John Wilson .	Copper and Galena	P. L. .	1,600	1st August 1910.	Do.
Do. .	(197) Mr. N. Samwell .	Gold . . .	P. L. .	6½ miles of the Bilin river.	18th November 1910.	Do.
Southern Shan States.	(198) Mr. F. H. Parry, on behalf of Dewalachi Galena Syndicate.	Lead, copper and other minerals (except mineral oil).	P. L. .	3,200	15th January 1910.	Do.
Do. .	(199) Messrs. Mower & Co.	Lead, copper and antimony.	P. L. .	3,200	31st December 1909.	Do.
Do. .	(200) Mr. R. H. Ady .	All minerals (except mineral oil).	P. L. .	2,560	26th April 1910.	Do.
Do. .	(201) Mr. D. Connel, on behalf of Dewalachi Galena Syndicate.	Lead, copper, etc.	P. L. (renewal).	1,600	25th August 1910.	Do.
Do. .	(202) Mr. J. Dumoulin .	Gold and silver .	P. L. (renewal).	160	12th August 1910.	Do.
Do. .	(203) Mr. F. H. Parry, on behalf of Dewalachi Galena Syndicate.	Lead, copper and other minerals.	P. L. (renewal).	3,200	29th June 1910.	Do.
Do .	(204) Mr. D. E. Smyth .	Copper and allied minerals.	P. L. .	1,440	18th November 1910.	Do.
Do .	(205) Lieut.-Col. G. Rippon.	Tungsten, tin, copper and associated minerals.	P. L. .	1,600	1st December 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(206) Mr. R. B. Levien	Minerals (except mineral oil).	P. L.	3,200	17th January 1910.	1 year.
Do.	(207) Messrs. Crisp & Co.	Tin, wolfram, gold and galena.	P. L.	3,200	23rd May 1910.	Do.
Do.	(208) Mr. B. A. Baldwin, on behalf of Messrs. Mower & Co.	Do.	P. L.	3,200	21st June 1910.	Do.
Do.	(209) Col. S. G. Radcliff, on behalf of Rangoon Mining Co.	Do.	P. L.	3,200	24th September 1910.	Do.
Do.	(210) Mr. B. A. Baldwin, on behalf of Messrs. Mower & Co.	Do.	P. L.	1,280	2nd July 1910.	Do.
Do.	(211) Do. do.	Do.	P. L.	3,200	9th September 1910.	Do.
Do.	(212) Mr. R. B. Levien	All minerals (except oil).	P. L.	3,200	16th August 1910.	Do.
Do.	(213) Do.	Do.	P. L.	1,280	Do.	Do.
Do.	(214) Chan Soo Don	Gold, wolfram and tin.	P. L.	1,920	26th August 1910.	Do.
Do.	(215) Messrs. Radcliff & Co.	Tin, wolfram, gold and galena.	P. L.	3,080	29th December 1910.	Do.
Do.	(216) Do. do.	Do.	P. L.	3,200	Do.	Do.
Do	(217) Do. do.	Do.	P. L.	3,123·20	Do.	Do.
Do.	(218) Tavoy Concessions, Limited.	Do.	P. L.	1,280	23rd December 1910.	Do.
Do.	(219) Do. do.	Tin, wolfram and gold.	P. L.	1,920	3rd December 1910.	Do.
Do.	(220) Yeo Eng Byan	All minerals (except oil).	P. L.	2,536	29th November 1910.	Do.
Do.	(221) Chan Soo Don	Do.	P. L.	2,600	3rd December 1910.	Do.
Do.	(222) Khoo Tun Byan	Do.	P. L.	3,200	29th December 1910.	Do.
Do.	(223) Quah Cheng Gwan.	Do.	P. L.	1,477	22nd December 1910.	Do.
Do.	(224) Maung Myat Thaing.	Do.	P. L.	2,246	3rd December 1910.	Do.
Do.	(225) Ung Kyee Pe Bros.	Do.	P. L.	1,190	1st November 1910.	Do.
Do.	(226) Khoo Tun Byan	Do.	P. L.	2,455	11th November 1910.	Do.
Do.	(227) Ung Kyee Pe Bros. & Co.	Do.	P. L.	2,741	3rd December 1910.	Do.
Do.	(228) Khoo Tun Byan	Do.	P. L.	2,854·40	31st December 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(229) Ma Mo Thu . .	All minerals (except oil).	P. L. .	3,200	3rd December 1910.	1 year.
Do. .	(230) Messrs. Radcliff & Co.	Do. . .	P. L. .	1,920	29th December 1910.	Do.
Do. .	(231) Khoo Tun Byan .	Do. . .	P. L. .	2,854	Do. .	Do.
Do. .	(232) Maung Myat Thaing & Co.	Do. . .	P. L. .	2,091	10th November 1910.	Do.
Do. .	(233) Teong Swee Siu .	Do. . .	P. L. .	2,712	8th December 1910.	Do.
Do. .	(234) Messrs. Hitakaree & Co.	Do. . .	P. L. .	3,193	1st December 1910.	Do.
Do. .	(235) Tenasserim Concessions, Ltd.	Do. . .	P. L. .	960	3rd November 1910.	Do.
Do. .	(236) Messrs. Hitakaree & Co.	Do. . .	P. L. .	2,919	2nd December 1910.	Do.
Do. .	(237) Do. do. .	Do. . .	P. L. .	1,195	31st October 1910.	Do.
Do. .	(238) Tenasserim Concessions, Ltd.	Do. . .	P. L. .	1,280	8th December 1910.	Do.
Do. .	(239) Tan Shwe Cho .	Do. . .	P. L. .	2,604·80	4th November 1910.	Do.
Do. .	(240) Yeo Eng Byan .	Do. . .	P. L. .	550	8th October 1910.	Do.
Do. .	(241) Khoo Zun Nee .	Do. . .	P. L. .	682	3rd December 1910.	Do.
Do. .	(242) Messrs. Hitakaree & Co.	Do. . .	P. L. .	2,881	2nd December 1910.	Do.
Do. .	(243) Do. do. .	Do. . .	P. L. .	2,737	Do. .	Do.
Do. .	(244) Tenasserim Concessions, Ltd.	Do. . .	P. L. .	3,200	15th October 1910.	Do.
Do. .	(245) Messrs. Radcliff & Co.	Do. . .	P. L. .	3,200	25th December 1910.	Do.
Do. .	(246) Shwe Oh Bros. & Co.	Do. . .	P. L. .	2,240	10th November 1910.	Do.
Do. .	(247) Chan Soo Don .	Do. . .	P. L. .	2,080	31st October 1910.	Do.
Do. .	(248) Maung Hpaw .	Do. . .	P. L. .	3,136	22nd December 1910.	Do.
Do. .	(249) Messrs. Radcliff & Co.	Do. . .	P. L. .	3,200	29th December 1910.	Do.
Do. .	(250) Maung Hpaw .	Do. . .	P. L. .	170	8th December 1910.	Do.
Do. .	(251) Khoo Jim Taik .	Do. . .	E. L. .	Whole district, excluding Forest Reserves.	7th December 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
hatôn .	(252) Mr. John Wilson .	Copper and galena	P. L. .	1,600	1st June 1910	1 year.
Do. .	(253) Messrs. Mower & Co.	Gold, copper, silver iron, and pyrites.	P. L. (renewal).	3,200	18th June 1910.	Do.
Do. .	(254) Messrs. Marshall Cotterell & Co.	Gold . .	P. L. .	1,600	10th August 1910.	Do.
Do. .	(255) Maung Ba Thaw .	Do. . . .	E. L. .	20 miles of Kyonpagu Chaung from its confluence with the Sittang river.	13th July 1910.	Do.
Do. .	(256) Do. do. .	Mica . . .	E. L. .	10	15th August 1910.	Do.
Do. .	(257) Messrs. Mower & Co.	Lead and silver .	P. L. .	2,560	8th October 1910.	Do.
Do. .	(258) Mr. N. Samwell .	Gold . .	P. L. .	3½ miles of the Bilin river.	Do. .	Do.
hayetmyo .	(259) Messrs. Finlay, Fleming & Co., Agents for the Burmah Oil Co., Ltd.	Petroleum . .	P. L. .	8,320	16th March 1910.	Do.
Do. .	(260) Messrs. Bawaney Brothers & Co.	Do. . .	P. L. .	2,880	17th January 1910.	Do.
Do. .	(261) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. . .	P. L. .	6,400	15th December 1909.	Do.
Do. .	(262) Messrs. Finlay Fleming & Co., Agent, for the Burmah Oils Co., Ltd.	Do. . .	P. L. .	960	12th April 1910.	Do.
Do. .	(263) Shamuddin . .	Do. . .	P. L. .	1,190·4	2nd June 1910	Do.
Do. .	(264) Messrs. A. S. Jamal Brothers & Co.	Do. . .	P. L. .	1,280	15th July 1910.	Do.
Do. .	(265) Do. do. .	Do. . .	P. L. .	1,280	6th July 1910	Do.
Do. .	(266) Messrs. Finlay, Fleming, & Co., Agents for the Burmah Oil Co., Ltd.	Do. . .	P. L. .	2,560	8th June 1910	Do.
Do. .	(267) Do. do. .	Do. . .	P. L. .	3,200	7th June 1910	Do.
Do .	(268) Do. do. .	Do. . .	P. L. .	640	Do. .	Do.
Do .	(269) Mr. G. C. Whigham, Agent for Burmah Oil Co., Ltd.	Do. . .	P. L. .	640	30th August 1910.	Do.
Do .	(270) Mr. H. B. Health Eves, Agent for Burmah Oil Co., Ltd.	Do. . .	P. L. .	1,440	29th August 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

BURMA—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Thayetmyo .	(271) Maung Tun Aung Gyaw.	Minerals and mineral oil.	E. L. .	12,480	27th July 1910.	1 year.
Do. .	(272) Maung Kyan Baw .	Petroleum . .	E. L. .	27,008	10th September 1910.	Do.
Do. .	(273) Chew Bah Gone .	Do. . .	P. L. .	966·40	2nd June 1910.	Do.
Do. .	(274) Maung Tun Aung Gyaw.	Minerals and petroleum.	E. L. .	13,440	2nd November 1910.	Do.
Do. .	(275) Do. do. .	Do. do. .	E. L. .	18,777·60	7th October 1910.	Do.
Toungoo .	(276) Messrs. Mower & Co.	Gold, arsenic and galena.	P. L. .	1,280	13th December 1910.	Do.
Do. .	(277) Mr. N. Samwell .	Gold . .	P. L. .	1,440	5th December 1910.	Do.
Do. .	(278) Joseph Po Kin .	Gold, silver, antimony and precious stones.	E. L. .	14,080	10th November 1910.	Do.
Upper Chindwin.	(279) Tan Po Chong and Yeo Eng Byan.	Petroleum . .	P. L. .	8,192	31st August 1910.	Do.
Yamethin .	(280) Mr. A. Campbell-Macmillan, Managing Director, Mount Pima Mining Co., Ltd.	Gold, silver, lead, copper and tin.	P. L. .	4,960	10th August 1909.	Do.

CENTRAL PROVINCES.

Balaghat .	(281) Mr. M. B. Chopra of Jubbulpore.	Manganese . .	P. L. .	422	2nd February 1910.	1 year.
Do. .	(282) Mr. D. Laxminarayan of Kamptee.	Do. . .	M. L. .	305	5th January 1910.	30 years.
Do. .	(283) Mr. Byramji Pestonji.	Manganese, lead, zinc, graphite, molybdenum, platinum and galena.	P. L. .	272	31st March 1910.	1 year.
Do. .	(284) Do. do. .	Manganese, copper, antimony, galena, graphite, wolfram, silicate of copper and malachite.	P. L. .	423	Do. .	Do.
Do. .	(285) The Bombay Prospecting and Mining Syndicate.	Manganese . .	P. L. .	744	16th March 1910.	Do.
Do. .	(286) Mr. Byramji Pestonji.	Manganese, copper zinc, and platinum.	P. L. .	288	31st March 1910.	Do.
Do. .	(287) Nagpur Manganese Mining Syndicate, Ltd.	Manganese . .	M. L. .	187	1st March 1910.	5 years.

E. L. denotes Exploring License, P. I., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(288) Mr. M. M. Mullna	Manganese	M. L.	195	31st March 1910.	30 years.
Do.	(289) Babu Kripa Shankar.	Do.	P. L.	514	12th March 1910.	1 year.
Do.	(290) Messrs. Ratanchand Kesrichand Chullany and Sons.	Mica	P. L.	148	31st January 1910.	Do.
Do.	(291) Lala Ganesh Prashad and Janki Prashad.	Manganese	M. L.	9	8th February 1910.	30 years.
Do.	(292) Mr. Byramji Pestonji.	Manganese, wolfram, copper, galena, antimony, tin and zinc.	P. L.	272	31st March 1910.	1 year.
Do.	(293) Mr. D. Laxminarayan.	Manganese	M. L.	9	5th January 1910.	30 years.
Do.	(294) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	94	25th February 1910.	1 year.
Do.	(295) Do. do.	All minerals	E. L.	20	Do.	Do.
Do.	(296) Mr. J. Kellerschon.	Manganese	M. L.	23	9th June 1910	30 years.
Do.	(297) Tata Iron and Steel Co.	Do.	M. L.	212	10th May 1910.	Do.
Do.	(298) Rai Sahib Mathura Prasad and Motilal.	Do.	M. L.	11	15th June 1910.	Do.
Do.	(299) Mr. E. C. Dungore	Do.	P. L.	14	25th June 1910.	1 year.
Do.	(300) Mr. D. Laxminarayan.	Do.	M. L.	25	9th June 1910.	30 years.
Do.	(301) Mr. C. Velu Aiyer	Do.	M. L.	104	6th May 1910	Do.
Do.	(302) Babu Kripa Shankar of Balaghat.	Do.	P. L.	66	2nd June 1910.	1 year.
Do.	(303) Central India Mining Co., Ltd.	Do.	M. L.	72	15th June 1910.	30 years.
Do.	(304) Babu Kripa Shankar.	Do.	P. L.	101	2nd June 1910.	1 year.
Do.	(305) Nagpur Manganese Mining Syndicate, Ltd.	Do.	P. L.	20	2nd April 1910.	Do.
Do.	(306) Babu Nago Bhimji	Do.	P. L.	28	28th June 1910.	Do.
Do.	(307) Do. do.	Do.	P. L.	78	Do.	Do.
Do.	(308) Babu Kripa Shankar.	All minerals	E. L.	1,680	25th April 1910.	Do.
Do.	(309) Central Provinces Prospecting Syndicate, Ltd.	Manganese	M. L.	4	19th September 1910.	22 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat	(310) Mr. R. K. Kanga	All minerals	E. L.	126,541	26th July 1910.	1 year.
Do.	(311) Seth Salikram	Red hematite	P. L.	23	26th August 1910.	Do.
Do.	(312) Do.	Do.	P. L.	126	Do.	Do.
Do.	(313) Dewan Bahadur Kasturchand Daga, C.I.E.	Manganese	M. L.	41	25th August 1910.	30 years.
Do.	(314) Do. do.	Do.	M. L.	61	Do.	Do.
Do.	(315) Nagpur Manganese Mining Syndicate, Ltd.	Do.	M. L.	18	2nd September 1910.	5 years.
Do.	(316) Khan Bahadur M. M. Mulna.	Do.	M. L.	103	8th September 1910.	30 years
Do.	(317) Do. do.	Do.	M. L.	44	Do.	Do.
Do.	(318) Rai Sahib Hiralal Sukul.	Do.	P. L.	626	26th September 1910.	1 year.
Do.	(319) Babu Kripa Shankar.	Do.	P. L.	104	Do.	Do.
Do.	(320) Rai Sahib Heralal Sukul.	Do.	P. L.	698	15th September 1910.	Do.
Do.	(321) Babu Kripa Shankar.	Do.	P. L.	112	26th September 1910.	Do.
Do.	(322) Tata Iron and Steel Co.	Do.	M. L.	149	8th September 1910.	5 years
Do	(323) Babu Kripa Shankar.	All minerals	E. L.	1,229	25th April 1910.	1 year.
Do.	(324) Mr. Byramji Pestonji.	Do.	E. L.	1,358	26th September 1910.	Do.
Do.	(325) Babu Kripa Shankar.	Do.	E. L.	1,682	21st September 1910.	Do.
Do.	(326) Mr. Byramji Pestonji.	Do.	E. L.	332	28th September 1910.	Do.
Do.	(327) Mr. Rambilash Murlidhar.	Manganese	P. L.	32	5th December 1910.	Do.
Do.	(328) Do. do.	Do.	P. L.	10	Do.	Do.
Do.	(329) Do. do.	Do.	P. L.	38	Do.	Do.
Do.	(330) Rao Bahadur Narayan Rao Kelkar.	Do.	P. L.	37	8th October 1910.	Do.
Do.	(331) Babu Kripa Shankar.	Do.	P. L.	240	16th December 1910.	Do.
Do.	(332) Mr. Byramji Pestonji.	Do.	P. L.	19	24th October 1910.	Do.
Do.	(333) Tata Iron and Steel Co.	Do.	M. L.	48	19th October 1910.	5 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(334) Messrs. Schroder, Smidt & Co.	Manganese . .	P. L. .	140	21st October 1910.	1 year.
Do. .	(335) Mr. Byramji Pestonji.	Do. . .	P. L. .	2	24th October 1910.	Do.
Do. .	(336) Messrs. Schroder, Smidt & Co.	Do. . .	P. L. .	350	19th December 1910.	Do.
Do. .	(337) Do. do. .	Do. . .	P. L. .	289	Do. .	Do.
Do. .	(338) Do. do. .	Do. . .	P. L. .	100	Do. .	Do.
Betul .	(339) Seth Lakshmichand	Graphite . .	P. L. .	91	4th January 1910.	Do.
Do. .	(340) Mr. P. E. Cameron	Coal .	E. L. .	13	5th December 1910.	6 months.
Bhandara .	(341) Mr Byramji Pestonji of Raipur.	Manganese . .	P. L. .	101	1st February 1910.	1 year.
Do. .	(342) Messrs. Kassambhoy, Ramji & Co. of Kamptee.	Do. . .	P. L. .	52	2nd February 1910.	Do.
Do. .	(343) Dewan Bahadur Kasturchand Daga.	Do. . .	M. L. .	283	21st February 1910.	30 years.
Do. .	(344) Central India Mining Co., Ltd.	Do. . .	M. L. .	146	2nd February 1910.	Do.
Do. .	(345) Messrs. Kassambhoy, Gopaldass and Mahadeo Seth.	Do. . .	P. L. .	43	28th January 1910.	1 year.
Do. .	(346) Messrs. Lalbehari Naraindas and Ramcharan Shankarlal.	Do.	M. L. .	25	25th January 1910.	10 years.
Do. .	(347) Central India Mining Co., Ltd.	Do. . .	P. L. .	199	9th February 1910.	1 year.
Do. .	(348) Seth Gowardhan Dass.	Do. . .	P. L. .	300	5th February 1910.	Do.
Do. .	(349) Mr. Hiralal Sukhul	Do. . .	P. L. .	84	1st March 1910.	Do.
Do. .	(350) Messrs. Bramhadutta and Baijnath.	Do. . .	P. L. .	56	25th April 1910.	Do.
Do.	(351) Mr. Hiralal Sukhul	Do. . .	M. L. .	21	8th June 1910	30 years.
Do. .	(352) Rai Sahib Mathura Prasad & Motilal.	Do. .	P. L. .	17	7th April 1910.	1 year.
Do. .	(353) Do. do.	Managanese, gold, silver, copper, lead and wolfram.	P. L. .	53	2nd April 1910.	Do.
Do. .	(354) Mr. Hiralal Sukhul .	Manganese .	P. L. .	644	19th April 1910.	Do.
Do. .	(355) Do. do. .	Do. . .	P. L. .	121	21st April 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara	(356) Messrs. Schroder, Smidt & Co.	Manganese	P. L.	451	11th June 1910.	1 year.
Do.	(357) Mr. Hiralal Sukhul.	Do.	P. L.	110	13th June 1910.	Do.
Do.	(358) Mr. Byramji Pestonji.	Do.	P. L.	10	16th April 1910.	Do.
Do.	(359) Do. do.	All minerals	E. L.	10	Do.	Do.
Do.	(360) Mr. P. Balkrishna Naidu.	Manganese	P. L.	197	13th June 1910.	Do.
Do.	(361) Rai Sahib Mathura Prasad, Motilal & Co.	Do.	M. L.	228	14th September 1910.	30 years.
Do.	(362) Mr. Byramji Pestonji.	Do.	M. L.	269	13th July 1910.	Do.
Do.	(363) Mr. Rambilas Murlidhar.	Do.	M. L.	94	2nd September 1910.	Do.
Do.	(364) Lala Ganesh Prasad, Janki Prasad and Brothers.	Do.	M. L.	11	20th June 1910.	Do.
Do.	(365) Seth Motilal Bansilal.	Do.	P. L.	6	9th September 1910.	1 year.
Do.	(366) Rai Sahib Mathura Prasad, Motilal & Co.	Do.	M. L.	257	3rd August 1910.	30 years.
Do.	(367) Messrs. L. R. Ramchandra & Co.	Do.	P. L.	450	Do.	1 year.
Do.	(368) Messrs. Schroder, Smidt & Co.	Do.	P. L.	410	25th July 1910.	Do.
Do.	(369) Do. do.	Do.	P. L.	266	15th July 1910.	Do.
Do.	(370) Rai Sahib Hiralal Sukul.	Do.	M. L.	78	5th September 1910.	30 years.
Do.	(371) Rai Sahib Mathura Prasad, Motilal & Co.	Do.	M. L.	18	3rd August 1910.	Do.
Do.	(372) Mr. P. Balkrishna Naidu.	Mica	P. L.	113	13th August 1910.	1 year.
Do.	(373) Messrs. Schroder, Smidt & Co.	Manganese	P. L.	318	21st July 1910.	Do.
Do.	(374) Messrs L. R. Ramchandra & Co.	Do.	P. L.	309	20th September 1910.	Do.
Do.	(375) Do. do.	All minerals	E. L.	450	3rd August 1910.	Do.
Do.	(376) Messrs. Lalbehari Naraindass and Ramcharan Shunkerlal.	Do.	E. L.	743	20th July 1910.	Do.
Do.	(377) Messrs. Bramhadutta and Baijnath.	Do.	E. L.	396	5th September 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bhandara .	(378) Seth Gowardhan Das.	Manganese . .	P. L. .	40	26th November 1910.	1 year.
Do. .	(379) Messrs. Ramprasad and Laxminarayan.	Do. . .	P. L. .	188	1st October 1910.	Do.
Do. .	(380) Mr. T. B. Kantharia.	Do. . .	M. L. .	55	14th October 1910.	30 years.
Do. .	(381) The Central India Mining Co.	Do. . .	M. L. .	27	4th November 1910.	Do. With effect from 24th March 1905.
Do. .	(382) Rai Sahib Hiralal Sukhul.	Do. . .	P. L. .	5	10th December 1910.	1 year.
Do. .	(383) Seth Gowardhan Das.	Do. . .	P. L. .	190	26th November 1910.	Do.
Do. .	(384) Mr. Dhawakmal Ganpatlal.	Do. . .	P. L. .	249	10th December 1910.	Do.
Bilaspur .	(385) Mr. R. K. Kanga .	Coal . . .	P. L. .	6,337	8th June 1910.	Do.
Do. .	(386) Mr. Khimji Cooverji.	Do. . .	P. L. .	4,595	29th June 1910.	Do.
Chanda .	(387) Mr. Byramji Pestonji.	Manganese, iron, copper, lead, wolfram, zinc and galena.	P. L. .	49	8th February 1910.	Do.
Do. .	(388) Do. do. .	Manganese, copper, lead, zinc wolfram, galena and iron.	P. L. .	25	Do. .	Do.
Do. .	(389) Do. do. .	Do. . .	P. L. .	284	Do. .	Do.
Do. .	(390) Rai Sahib Mathura Prasad, Motilal & Co.	All minerals .	E. L. .	478	30th March 1910.	Do.
Do. .	(391) Messrs. H. Varma and M. Kanhayalal.	Coal . . .	P. L. .	2,383	31st May 1910.	Do.
Do. .	(392) Rai Sahib Mathura Prasad and Motilal.	Felspar and steatite.	P. L. .	23	21st April 1910.	Do.
Do. .	(393) Messrs. Kanahyalal and Varma.	Coal . . .	E. L. .	2,368	28th October 1910.	Do.
Chhindwara .	(394) Messrs. Shaw, Wallace & Co.	Do. . .	P. L. .	10,919	23rd March 1910.	Do.
Do. .	(395) Seths Ramlal and Sukhlal.	Do. . .	P. L. .	500	23rd February 1910.	Do.
Do. .	(396) Indian Manganese Co., Ltd.	Manganese . .	P. L. .	1,437	4th February 1910.	Do.
Do. .	(397) Messrs. V. D. Salpekar and Kartarbaksh.	Do. . .	P. L. .	71	18th January 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(398) Mr. A. C. Blechynden of Jubbulpore.	Manganese . .	P. L. .	68	31st January 1910.	1 year.
Do. .	(399) Seth Pokarmal Beharilal.	Do. . .	P. L. .	125	7th February 1910.	Do.
Do. .	(400) Messrs. V. D. Salpekar and Kartarbaksh.	Do. . .	M. L. .	204	7th March 1910.	30 years.
Do. .	(401) Seth Ratanchand Keshirchand.	All minerals .	E. L. .	295	22nd June 1910.	1 year.
Do. .	(402) Messrs. V. D. Salpekar and Kartarbaksh.	Manganese . .	M. L. .	164	6th July 1910.	30 years.
Do. .	(403) Khan Bahadur Ali Raza Khan.	Coal . . .	P. L. .	495	8th August 1910.	1 year.
Do. .	(404) Seth Ratanchand and Kesrichand Chullany.	Manganese . .	P. L. .	295	29th July 1910.	Do.
Do. .	(405) Mr. Byramji Pestonji.	All minerals .	E. L. .	757	17th October 1910.	Do.
Drug . .	(406) Jubbulpore Prospecting Syndicate.	Do. . .	E. L. .	369	27th April 1910.	Do.
Do. . .	(407) Do. do. .	Gold, silver, copper and lead.	P. L. .	116	Do. .	Do.
Do. . .	(408) Messrs. Bahmansha Fouzdar Brothers.	Gold, silver, bauxite, cobalt, copper and lead.	M. L. .	36	20th June 1910	30 years
Hoshangabad	(409) Messrs. R. K. Chullany and Sons.	All minerals .	E. L. .	1,181	24th January 1910.	1 year.
Do. .	(410) Seth Sukhdeo and Harishankar of Harda.	Coal and bauxite	P. L. .	520	30th June 1910.	Do.
Jubbulpore .	(411) Mr. Rustomji Kekobad Kanga.	Manganese and iron.	P. L. .	395	4th March 1910.	Do.
Do .	(412) Do. do. .	Do. . .	P. L. .	156	17th January 1910.	Do.
Do. .	(413) Messrs. Venkatramannah and Brothers.	Copper . .	P. L. .	421	23rd March 1910.	Do.
Do. .	(414) Mr. C. Jambon .	Iron and coal .	P. L. .	2,499	10th February 1910.	Do.
Do. .	(415) Bombay Prospecting and Mining Syndicate, Ltd.	Steatite and talc .	P. L. .	170	28th February 1910.	Do.
Do. .	(416) Mr. D. W. A. Macdonald.	Bauxite . .	M. L. .	141	16th February 1910.	30 years.
Do. .	(417) Messrs. C. Macdonald & Co., Bombay.	All minerals .	E. L. .	1,890	18th January 1910.	1 year.
Do. .	(418) Messrs. Carnegie Steel Co., Pittsburg (Mr. J. Kellerschon).	Manganese . .	M. L. .	42	13th April 1910.	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jubbulpore .	(419) Mr. D. W. A. Macdonald.	All minerals .	E. L. .	576	19th April 1910.	1 year.
Do. .	(420) Mr. M. B. Chopra .	Graphite, talc, and steatite.	P. L. .	206	16th August 1910.	Do.
Do .	(421) The Bombay Prospecting and Mining Syndicate.	Bauxite . .	P. L. .	511	1st June 1910	Do.
Do. .	(422) Messrs. C. Macdonald & Co.	Iron . . .	P. L. .	633	31st August 1910.	Do.
Nagpur .	(423) Hon'ble Mr. M. B. Dadabhoy.	Manganese . .	P. L. .	240	2nd February 1910.	Do.
Do. .	(424) Mr. Byramji Pestonji of Raipur.	Manganese, molybdenum, tin, zinc, galena and platinum.	P. L. .	120	Do. .	Do.
Do. .	(425) Mr. Byramji Pestonji.	Manganese and copper.	P. L. .	481	Do. .	Do.
Do. .	(426) Do. do. .	Manganese, molybdenum, lead, zinc, wolfram, graphite and platinum.	P. L. .	426	Do. .	Do.
Do. .	(427) Mr. F. C. Dungore	Manganese . .	P. L. .	60	2nd February 1910.	Do.
Do. .	(428) Mr. Gopal Sheoram Dawe.	Do. . .	P. L. .	633	10th March 1910.	Do.
Do. .	(429) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	104	Do. .	Do.
Do. .	(430) Messrs. Ratanchand Kesrichand Chullany and Sons.	Do. . .	M. L. .	159	15th March 1910.	30 years.
Do. .	(431) Messrs. Shawaksha Jamshetji Dubash and Bapuji Jamshetji Dubash.	Manganese, wolfram, antimony and mica.	P. L. .	45	2nd February 1910.	1 year.
Do. .	(432) Mr. Madhulal Doogar.	Manganese . .	M. L. .	17	22nd March 1910.	30 years.
Do. .	(433) Messrs. Shawaksha Jamshetji Dubash and Bapuji Jamshetji Dubash.	Manganese, wolfram, antimony and mica.	P. L. .	97	2nd February 1910.	1 year.
Do. .	(434) Lala Bansilal Kalar	Manganese . .	P. L. .	15	10th January 1910.	Do.
Do. .	(435) Mr. Balkrishna Rupchand, on behalf of Rupchand Galbiram.	Do. . .	P. L. .	848	10th March 1910.	Do.
Do. .	(436) Lala Bansilal Kalar	Do. . .	P. L. .	39	15th February 1910.	Do.
Do. .	(437) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	P. L. .	128	24th February 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(438) Lala Bansilal Kalar	Manganese . .	P. L. .	117	24th February 1910.	1 year.
Do. .	(439) Do. do. .	Do. . .	P. L.	282	Do. .	Do.
Do. .	(440) Do. do. .	Do. . .	P. L. .	98	15th February 1910.	Do.
Do. .	(441) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	P. L. .	92	10th January 1910.	Do.
Do. .	(442) Do. do. .	All minerals .	E. L. .	236	2nd February 1910.	Do.
Do. .	(443) Do. do. .	Do. .	E. L. .	1,161	Do. .	Do.
Do. .	(444) Do. do. .	Do. .	E. L. .	66	10th January 1910.	Do.
Do. .	(445) Do. do. .	Do. .	E. L. .	93	2nd February 1910.	Do.
Do. .	(446) Do. do. .	Do. .	E. L. .	115	Do. .	Do.
Do. .	(447) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Do. .	E. L. .	270	23rd March 1910.	Do.
Do. .	(448) Mr. Motilal Saokar	Do. .	E. L. .	180	Do. .	Do.
Do. .	(449) Mr. P. Balkrishna Naidu.	Do. .	E. L. .	63	21st March 1910.	Do.
Do. .	(450) Mr. G. M. Prichard	Do. .	E. L. .	206	23rd March 1910.	Do.
Do. .	(451) Central India Mining Co., Ltd.	Manganese . .	M. L. .	191	6th May 1910	30 years.
Do. .	(452) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	217	10th May 1910.	1 year.
Do. .	(453) Mining and Prospecting Syndicate, Kamptee.	Do. . .	P. L. .	570	1st June 1910	Do.
Do. .	(454) Mr. Byramji Pestonji.	Do. . .	P. L. .	309	29th April 1910.	Do.
Do. .	(455) Mr. Shamji Madhoji.	Do. . .	P. L. .	27	6th June 1910	Do.
Do. .	(456) Central India Mining Co., Ltd.	Wolfram . .	P. L. .	127	15th April 1910.	Do.
Do. .	(457) Do. do. .	Do. . .	P. L. .	694	20th June 1910.	Do.
Do. .	(458) Mr. Byramji Pestonji.	Manganese, antimony, galena, platinum, tin, wolfram and zinc.	P. L. .	89	29th April 1910.	Do.
Do. .	(459) Messrs. Ramprasad and Laxminarayan.	Manganese . .	M. L. .	62	21st May 1910.	30 years.
Do. .	(460) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	M. L. .	8	11th May 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(461) Messrs. Shawaksha Jamshetji Dubash and Bapuji Jamshetji Dubash.	Manganese, mica and wolfram.	P. L. .	10	19th April 1910.	1 year.
Do. .	(462) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Manganese . .	M. L. .	8	16th June 1910.	5 years.
Do. .	(463) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	69	10th May 1910.	1 year.
Do. .	(464) Do. do. .	Do. . .	P. L. .	434	Do. .	Do.
Do. .	(465) Mr. T. B. Kantharia.	Do. . .	M. L. .	100	9th April 1910.	30 years.
Do. .	(466) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	M. L. .	8	11th May 1910.	Do.
Do. .	(467) Messrs. Shawaksha Jamshetji Dubash and Bapuji Jamshetji Dubash.	Manganese, mica, antimony and wolfram.	P. L. .	37	19th April 1910.	1 year.
Do. .	(468) Nagpur Manganese Mining Syndicate, Ltd.	Manganese . .	P. L. .	292	23rd May 1910.	Do.
Do. .	(469) Do. do. .	Do. . .	P. L. .	72	1st April 1910.	Do.
Do. .	(470) Do. do. .	All minerals .	E. L. .	170	Do.	Do.
Do. .	(471) Do. do. .	Manganese . .	P. L. .	66	15th April 1910.	Do.
Do. .	(472) Do. do. .	Do. .	P. L. .	75	23rd May 1910.	Do.
Do. .	(473) Do. do. .	Do. . .	P. L. .	143	Do. .	Do.
Do. .	(474) Messrs. Schroder, Smidt & Co.	Do. . .	P. L. .	75	29th April 1910.	Do.
Do. .	(475) Mr. Byramji Pestonji.	Manganese, galena, copper and wolfram.	P. L. .	33	18th May 1910.	Do.
Do. .	(476) Nagpur Manganese Mining Syndicate, Ltd.	Manganese . .	P. L. .	93	15th April 1910.	Do.
Do. .	(477) Do. do. .	Do. . .	P. L. .	115	28th June 1910.	Do.
Do. .	(478) Mr. P. Balkrishna Naidu.	Do. . .	P. L. .	152	15th June 1910.	Do
Do. .	(479) Nagpur Manganese Mining Syndicate, Ltd.	Do . .	P. L. .	25	23rd May 1910.	Do.
Do. .	(480) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Do. . .	P. L. .	56	1st June 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(481) Mr. Hariram Sitaram Patel.	Manganese . .	P. L. .	289	27th June 1910.	1 year.
Do. .	(482) Mr. Motilal Saokar	Do. . .	P. L. .	64	10th May 1910.	Do.
Do. .	(483) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	All minerals .	E. L. .	315	1st June 1910.	Do.
Do. .	(484) Mr. Motilal Saokar	Do. .	E. L. .	98	15th April 1910.	Do.
Do. .	(485) Do. do. .	Do. .	E. L. .	172	23rd May 1910.	Do.
Do. .	(486) Do. do. .	Do. .	E. L. .	58	Do. .	Do.
Do. .	(487) Nagpur Manganese Mining Syndicate, Ltd.	Manganese . .	P. L. .	119	28th June 1910.	Do.
Do. .	(488) Mr. Motilal Saokar	Do. .	P. L. .	48	27th June 1910.	Do.
Do. .	(489) Nagpur Manganese Mining Syndicate.	Do. .	P. L. .	31	28th June 1910.	Do.
Do. .	(490) Mr. Byramji Pestonji.	All minerals .	E. L. .	33	29th April 1910.	Do.
Do. .	(491) Rai Bahadur Bansilal Abirchand Mining Syndicate.	Manganese . .	M. L. .	217	24th September 1910.	30 years.
Do. .	(492) Central India Mining Co.	Do . .	M. L. .	66	26th September 1910.	Do.
Do. .	(493) Messrs. C. Macdonald & Co., Bombay.	Manganese, iron, bismuth, copper, molybdenum, tin and wolfram.	P. L. .	1,281	19th July 1910.	1 year.
Do. .	(494) Mr. E. Nagannah Naidu.	Manganese .	P. L. .	16	6th September 1910.	Do.
Do. .	(495) Hon'ble Mr. M. B. Dadabhoy.	Do. . .	P. L. .	227	16th August 1910.	Do.
Do. .	(496) Messrs. Radhakisan Brothers.	Do. . .	P. L. .	13	11th August 1910.	Do.
Do. .	(497) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	P. L. .	27	12th July 1910.	Do.
Do. .	(498) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Do. . .	P. L. .	118	16th August 1910.	Do
Do. .	(499) Mr. Govind Rao Baji Rao.	Do. . .	M. L. .	82	31st August 1910.	30 years.
Do. .	(500) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	P. L. .	170	12th July 1910.	1 year.
Do. .	(501) Do. do. .	Do. . .	P. L. .	176 .	16th August 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur	(502) Mr. Byramji Pestonji.	Manganese	M. L.	8	8th July 1910	5 years.
Do.	(503) Mr. Byramji D. Dungaji.	Do.	P. L.	250	11th August 1910.	1 year.
Do.	(504) Messrs. Brambhadutta and Baijnath.	Do.	P. L.	72	8th September 1910.	Do.
Do.	(505) Nagpur Manganese Mining Syndicate, Ltd.	Do.	M. L.	63	2nd September 1910.	30 years.
Do.	(506) Lala Bansilal Kalar.	Do.	P. L.	38	27th July 1910.	1 year.
Do.	(507) Messrs. Radhakisan Brothers.	Do.	P. L.	7	4th July 1910	Do.
Do.	(508) Messrs. Schroder, Smidt & Co.	Do.	P. L.	684	16th September 1910.	Do.
Do.	(509) Seth Balkrishna, Proprietor of the Firm of Roopchand Galbiram.	Do.	P. L.	41	17th September 1910.	Do.
Do.	(510) Do. do.	Do.	P. L.	51	Do.	Do.
Do.	(511) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Do.	P. L.	279	23rd September 1910.	Do.
Do.	(512) Nagpur Manganese Mining Syndicate, Ltd.	All minerals	E. L.	144	1st April 1910	Do.
Do.	(513) Mr. Motilal Saokar	Manganese	P. L.	29	16th August 1910.	Do.
Do.	(514) Do. do.	Do.	P. L.	83	19th August 1910.	Do.
Do.	(515) Do. do.	Do.	P. L.	220	19th July 1910.	Do.
Do.	(516) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Do.	P. L.	3	16th August 1910.	Do.
Do.	(517) Mr. Byramji Pestonji.	Do.	P. L.	33	11th August 1910.	Do.
Do.	(518) Nagpur Manganese Mining Syndicate, Ltd.	Do.	M. L.	72	2nd September 1910.	10 years.
Do.	(519) Mr. Byramji Pestonji.	Do.	P. L.	166	6th September 1910.	1 year.
Do.	(520) Do. do	All minerals	E. L.	166	11th August 1910.	Do.
Do.	(521) Nagpur Manganese Mining Syndicate, Ltd.	Manganese	P. L.	454	23rd September 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(522) Dewan Bahadur Kasturchand Daga, C.I.E.	Manganese . .	P. L. .	106	9th September 1910.	1 year.
Do. .	(523) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	P. L. .	14	23rd September 1910.	Do.
Do. .	(524) Do. do. .	All minerals .	E. L. .	14	16th August 1910.	Do.
Do. .	(525) Mr. Byramji Pestonji.	Do. . .	E. L. .	44	28th September 1910.	Do.
Do. .	(526) Messrs. Bahmansha Fouzdar Brothers.	Do. . .	E. L. .	1,081	16th August 1910.	Do.
Do. .	(527) Nagpur Manganese Mining Syndicate, Ltd.	Do. . .	E. L. .	86	23rd September 1910.	Do.
Do. .	(528) Mr. Laxman Damodar Lele.	Do. . .	E. L. .	12	17th September 1910.	Do.
Do. .	(529) The Bansilal Abirchand Mining Syndicate.	Manganese .	M. L. .	449	8th December 1910.	30 years.
Do. .	(530) Mr. M. B. Chopra .	Manganese, mica and wolfram.	P. L. .	19	29th November 1910.	1 year.
Do. .	(531) Mr. E. Nagannah Naidu.	Manganese .	M. L. .	52	4th October 1910.	30 years.
Do. .	(532) Mr. T. B. Kantharia.	Do. . .	M. L. .	40	14th October 1910.	Do.
Do. .	(533) Messrs. Shawaksha Jamsetji Dubash and Bapuji Jamsetji Dubash.	Manganese, wolfram and antimony.	P. L. .	129	25th October 1910.	1 year.
Do. .	(534) Mr. E. Nagannah Naidu.	Manganese . .	M. L. .	17	8th December 1910.	30 years.
Do. .	(535) Mr. Byramji Pestonji.	Do. . .	E. L. .	488	25th October 1910.	1 year.
Do. .	(536) Messrs. Schroder, Smidt & Co.	Do. . .	P. L. .	533	9th December 1910.	Do.
Do. .	(537) Mr. T. Cooverji Bhoja.	Do. . .	P. L. .	33	15th November 1910.	Do.
Do. .	(538) Messrs. L. R. Ramchander & Co.	Do. . .	P. L. .	117	29th November 1910.	Do.
Do. .	(539) Messrs. P. S. Kotwal and S. R. Naidu.	Manganese, iron, bismuth, wolfram and molybdenum.	P. L. .	153	9th November 1910.	Do.
Do. .	(540) Mr. Motilal Saokar.	Manganese . .	P. L. .	93	15th October 1910.	Do.
Do. .	(541) Mr. T. B. Kantharia.	Do. . .	M. L. .	90	10th December 1910.	30 years.
Do. .	(542) Do. do. .	Do. . .	M. L. .	86	Do. .	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CENTRAL PROVINCES—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(543) Messrs. Lalbehari Naraindass and Ramcharan Shankarlal.	Manganese . .	P. L. .	244	15th October 1910.	1 year
Do.	(544) Messrs. Kasambhoy Ramji & Co.	Do. . .	P. L. .	83	22nd November 1910.	Do.
Do. .	(545) Messrs. L. R. Ramchander & Co.	Do. . .	P. L. .	45	29th November 1910.	Do.
Do. .	(546) Do. do. .	Do. . .	P. L. .	71	Do. .	Do.
Do. .	(547) Mr. Dhawakmal Ganpatlal.	Do. . .	E. L. .	800	15th October 1910.	Do.
Do. .	(548) Messrs. Ganeshram Sheopratab and Sons.	Do . .	P. L. .	142	24th October 1910.	Do
Do. .	(549) Nagpur Manganese Mining Syndicate.	Do. . .	P. L. .	86	25th October 1910.	Do
Do. .	(550) Messrs. Bahmansha Fouzdar Brothers.	Do. . .	P. L. .	46	Do. .	Do.
Do. .	(551) Mr. Laxman Damodar Lele.	Do. . .	P. L. .	12	Do. .	Do.
Do. .	(552) Do. do. .	Do. . .	P. L. .	11	7th December 1910.	Do.
Do. .	(553) Mr. Byramji Pestonji.	Do. . .	E. L. .	77	25th October 1910.	Do.
Do .	(554) Mr. Laxman Damodar Lele.	Do. . .	E. L. .	11	Do. .	Do.
Do. .	(555) Mr. Byramji Pestonji.	Do. . .	E. L. .	97	Do. .	Do.
Do. .	(556) Mr. Motilal Saokar.	Do. . .	E. L. .	627	25th November 1910.	Do.
Do. .	(557) Mr. T. P. Kantharia.	Do. . .	E. L. .	257	9th November 1910.	Do.
Do. .	(558) Do. do. .	Do. . .	E. L. .	218	Do. .	Do.
Do. .	(559) Do. do. .	Do. . .	E. L. .	67	Do. .	Do.
Do. .	(560) Mr. Laxman Damodar Lele.	Do. . .	E. L. .	301	Do. .	Do.
Do. .	(561) Nagpur Manganese Mining Syndicate.	Do. . .	E. L. .	355	Do. .	Do.
Do. .	(562) Mr. Laxman Damodar Lele.	Do. . .	E. L. .	108	1st December 1910.	Do.
Raipur .	(563) Nagpur Manganese Mining Syndicate, Ltd.	All minerals .	E. L. .	504	12th February 1910.	Do.
Do. .	(564) Mr. Byramji Pestonji.	Do. . .	E. L. .	55	28th April 1910.	Do.
Do. .	(565) Nagpur Manganese Mining Syndicate, Limited.	Graphite . .	P. L. .	222	19th May 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining L

CENTRAL PROVINCES—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Raipur . .	(566) Mr. T. B. Kanthария of Kamptee.	All minerals .	E. L. .	6,132	20th June 1910.	1 year.
Do. . .	(567) Mr. Byramji Pestonji.	Graphite, antimony, wolframite, copper, lead and galena.	P. L. .	355	24th October 1910.	Do.
Saugor . .	(568) Mr Rustomji Kekobad Kanga.	Manganese and iron.	P. L. .	494	28th February 1910.	Do
Do. . .	(569) Do. do. .	Do. .	P. L. .	1,104	Do. .	Do.
Do. . .	(570) Mr. Beharilal Rai, Bar.-at-Law, Saugor.	All minerals .	E. L. .	111	27th May 1910.	Do.
Seoni . .	(571) Messrs. Ratanchand Keshrichand Chullany and Sons.	Felspar . .	P. L. .	284	4th October 1910.	Do.
Do. . .	(572) Mr. Byramji Pestonji.	Manganese . .	E. L. .	2,109	17th October 1910.	Do.

EASTERN BENGAL AND ASSAM.

Cachar . .	(573) Mr. W. G. Stoker, Cachar.	Mineral oil and other minerals.	E. L. .	Land around the Badarpur tea estate.	4th November 1910.	1 year.
Chittagong .	(574) Messrs. Bullock Brothers & Co., Agent. on behalf of the Burmah Oil Co., Ltd., Chittagong.	Oil . . .	P. L. .	3,648	15th April 1910.	Do.
Khasi and Jaintia Hills.	(575) Mr. P. N Sen, Solicitor, Calcutta.	Do. . .	P. L. .	5,120	22nd August 1910.	Do.
Do. .	(576) Mr R. N. Shadwell of Cherrapunji.	Petroleum . .	P. L. .	1,280	22nd October 1910.	Do.
Khasi and Jaintia Hills, Sylhet and Cachar.	(577) Mr. J. Henry Brook, Calcutta.	Do. . .	P. L. .	31,360	24th September 1910.	Do.
Lakhimpur .	(578) The Assam Railways and Trading Co., Ltd., of Dibrugarh.	Coal, iron, slate and shales.	M. L.	640	1st April 1910	30 years.

MADRAS.

Bellary . .	(579) F. F. Dinna . .	Manganese . .	P. L.	319·09	25th January 1910.	1 year.
Do. . .	(580) The Southern Indian Manganese Company, Limited.	Do. . .	M. L. .	1,132·80	24th March 1910.	30 years.

E. L. denotes Exploring Licence, P. L., Prospecting Licence, and M. L., Mining Lease.

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Coimbatore	(581) Gobindji Odoji Sait	Corundum	P. L.	12·00	19th November 1910.	1 year.
Cuddapah	(582) Bavadin & Co.	Copper	P. L.	640	26th January 1910.	Do.
Do.	(583) Shaik Meera Sahib & Co.	Barytes or barium sulphate.	P. L.	8·60	5th June 1910	Do.
Do.	(584) Do. do.	Do. do.	P. L.	30·00	Do.	Do.
Kistna	(585) Shaw, Wallace & Co., for Southern India Coal Mining Syndicate (Limited), Madras.	Coal	E. L.	150·072	14th April 1910.	Do.
Kurnool	(586) A. Ghose of Tarikera.	Diamonds	P. L.	697·13	26th January 1910.	Do.
Do	(587) Sir H. King	All minerals	E. L.	9,216	27th January 1910.	Do.
Madura	(588) P. N. Bose	Crystalline limestone	P. L.	2·21	1st March 1910.	Do.
Nellore	(589) K. Penchal Reddi	Mica	P. L.	19·83	8th February 1910.	Do.
Do.	(590) Madras Mica Export Company.	Do.	E. L.	Not stated.	28th January 1910.	Do.
Do.	(591) B. Narasa Reddi	Do.	M. L. (renewal)	163·60	21st March 1910.	27 years.
Do.	(592) Do. do.	Do.	M. L.	3·05	22nd May 1910.	Do.
Do.	(593) K. Krishnaswami Mudalyar.	Do.	P. L. (renewal).	12·92	24th April 1910.	1 year.
Do.	(594) Do. do.	Do.	P. L. (renewal).	14·00	14th April 1910.	Do.
Do.	(595) Rebala Lakshmi Narasa Reddi.	Do.	P. L.	19·98	11th May 1910.	Do.
Do.	(596) Moulvie Muhammad Asad-ud-din Sahib, Ansari.	Do.	P. L. (renewal).	15·17	2nd June 1910.	Do.
Do.	(597) Do. do.	Do.	P. L. (renewal).	19·72	Do.	Do.
Do.	(598) George Illgen	Do.	P. L. (renewal).	142·88	Do.	Do.
Do.	(599) Kalicheti Panchalu Reddi.	Do.	P. L.	17·95	4th July 1910	Do.
Do.	(600) Ponaka Balarami Reddi.	Do.	M. L. (patta land).	3·09	1st July 1910	20 years.
Do.	(601) Messrs. T. R. Tawker & Sons.	All minerals	E. L.	(Not reported)	10th August 1910.	1 year.
Do.	(602) Muhammad Ziauddin.	Mica	P. L.	12·30	8th September 1910.	Do.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

MADRAS—*contd.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore . .	(603) The Madras Mica Export Company.	Mica . . .	P. L. .	42·21	17th July 1910.	1 year.
Do. . .	(604) Mr. George Illgen .	Do. . . .	P. L. .	10·86	25th July 1910.	Do.
Do. .	(605) Do. do. .	Do. . . .	P. L. .	10·45	Do. .	Do.
Do. . .	(606) Do. do. .	Do. . . .	P. L. .	12·32	Do. .	Do.
Do. . .	(607) Do. do. .	Do. . . .	P. L. .	36·57	Do. .	Do.
Do. . .	(608) Do. do. .	Do. . . .	P. L. .	20·75	Do. .	Do.
Do. . .	(609) Burla Bala Rami Reddi.	Do. . . .	M. L. (patta land).	4·25	24th March 1910.	20 years.
Do. . .	(610) Rebala Babu Reddi	Do. . . .	M. L. .	19·06	27th July 1910.	30 years.
Do . .	(611) G. Subramanyam .	Do. . . .	P. L. .	23·96	27th October 1910.	1 year.
Do. . .	(612) Madras, Mica Export Company.	Do. . . .	P. L. .	58·03	17th July 1910.	Do.
Do. . .	(613) V. Venkatasubbaya Nayudu.	All minerals .	E. L. .	All unoccupied and Government reserved lands of Gudur, Rapur and Atmakur Taluks in the Nellore District.	14th October 1910.	Do.
Do. . .	(614) G. Subramanyam	Mica . .	P. L. .	11·20	4th October 1910.	Do.
Do. .	(615) P. Venkatrama Nayudu.	Do. . . .	P. L. .	13·25	22nd September 1910.	Do.
Salem . .	(616) Sir H. King . .	Galena . .	P. L. .	36·78	26th January 1910.	Do.
Do. . .	(617) The Anglo-Indian Trading Company.	Magnesite and corundum.	P. L. .	403·10	17th February 1910.	Do.
Do. . .	(618) Mr. James Short .	Do. . . .	P. L. .	54·63	26th January 1910.	Do.
Do. . .	(619) The Anglo-Indian Trading Company.	Magnesite . .	M. L. .	26·77	2nd April 1910.	7 years.
Do. .	(620) Mr. James Short .	Do. . . .	M. L. .	358·41	11th March 1910.	30 years.
Do. . .	(621) T. R. Venkataramana Aiyar.	Mica . . .	E. L. .	3,702·84	3rd August 1910.	1 year.
Do. . .	(622) The Anglo-Indian Trading Company.	Corundum . .	P. L. .	91·52	19th September 1910.	Do.
Do. . .	(623) T. R. Venkataramana Aiyar.	Mica . .	M. L. .	3·71	6th July 1910	30 years.

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

MADRAS—*concld.*

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Salem . .	(624) T. R. Venkataramana Aiyar.	Mica . .	M. L. .	64·02	21st November 1910.	30 years.
Do. . .	(625) Sir H. King . .	Galena . .	E. L. .	163·16	26th November 1910.	1 year.
Tinnevelly .	(626) Morgan Crucible Company.	Plumbago . .	E. L. .	The whole taluk.	30th May 1910.	Do.
Do. .	(627) M. R. Ry T. R. Malaiyappa Aiyar Avargal.	Do. . . .	P. L. .	30·84	25th July 1910.	Do.
Trichinopoly .	(628) Thomas Lieshman .	Wolframite .	E. L. .	400	28th February 1910.	Do.

PUNJAB.

DISTRICT.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum . .	(629) Thakar Das and Ramji Das.	Coal . . .	P. L. (renewal).	283·51	14th February 1910.	1 year.
Do. . .	(630) Lala Ishar Das .	Do. . .	P. L. .	100	11th April 1910.	Do.
Do. . .	(631) Pandit Bhola Nath.	Do. . . .	P. L. (renewal).	55	20th July 1910.	Do.
Mianwali .	(632) Messrs. J. G. Bagram & Co., of Calcutta.	Mineral oil . .	P. L. .	6,400	Not fixed yet	Do.
Do. .	(633) Do. do. .	Do. . .	P. L. .	4,160	Do. .	Do.
Do. .	(634) Do. do. .	Do. . .	P. L. .	6,400	Do. .	Do.
Do. .	(635) The Manager, North Western Railway.	Coal . . .	P. L. .	455	15th July 1910.	Do.

SUMMARY.

Provinces.	Prospecting Licenses.	Exploring Licenses.	Mining Leases.	Total of each Province.
Baluchistan	1	..	8	9
Bengal	26	1	48	75
Bombay	..	2	3	5
Burma	156	30	5	191
Central Provinces	176	59	57	292
Eastern Bengal and Assam	4	1	1	6
Madras	31	9	10	50
Punjab	7	..	..	7
Total for each kind and Grand Total, 1910 .	**401**	**102**	**132**	**635**
Totals for 1909 .	*394*	*143*	*156*	*693*

E. L. denotes Exploring License, P. L., Prospecting License, and M. L., Mining Lease.

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 28.—*Prospecting and Mining Licenses granted in Baluchistan during 1910.*

DISTRICT.	1910. No.	Area in acres.	Mineral.
Prospecting Licenses.			
Quetta . . .	1	432	Coal.
TOTAL .	1	..	
Mining Leases.			
Kalat	1	213	Coal.
Quetta	1	80	Chromite.
Sibi	1	160	Coal.
Zhob	5	585	Chromite.
TOTAL .	8	..	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Bengal during 1910.*

Prospecting Licenses.

Hazaribagh	13	2,098·07	Mica.
Puri	1	640	Lead and its oxides.
Sambalpur	1	1,123·52	Coal.
Do.	1	230·20	Mica and steam coal.
Singhbhum	9	10,067·2	Manganese.
Do.	1	2,160	Gold.
TOTAL .	26	..	

TABLE 29.—*Prospecting Licenses and Mining Leases granted in Bengal during 1910*—contd.

DISTRICT.	1910.		
	No.	Area in acres.	Mineral.
Mining Leases.			
Hazaribagh	44	7,715·385	Mica.
Sambalpur	1	3,155·2	Coal.
Singhbhum	3	7,289·60	Iron-ore
TOTAL .	48	. .	

TABLE 30.—*Mining Leases granted in Bombay during 1910.*

Mining Leases.

Panch Mahals	2	639	Manganese.
Ratnagiri	1	12	Do.
TOTAL .	3	. .	

TABLE 31.—*Prospecting Licenses and Mining Leases granted in Burma during 1910.*

Prospecting Licenses.

Akyab	3	10,880	Petroleum.
Amherst	1	620·73	Silver and gold.
Do.	1	7,398	Gold, silver, tin, copper, lead and antimony.
Henzada	2	9,834	Petroleum.
Do.	1	3,002·88	Coal.
Katha	1	1,600	Gold.
Do.	1	2,464	Lead.
Magwe	11	34,483·03 and two blocks.	Petroleum.
Mandalay	1	320	Galena, gold, silver and copper.

TABLE 31.—*Prospecting Licenses and Mining Leases granted in Burma during 1910*—contd.

DISTRICT.	1910.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Mandalay	2	2,480	Lead, copper, silver, gold and iron.
Do.	1	1,280	Silver, lead, zinc and copper.
Meiktila	2	2,560	Lead and copper.
Mergui	13	27,920	Tin, wolfram, etc.
Do.	3	8,320	All minerals.
Do.	1	3,200	Manganese.
Do.	1	2,611·2	Coal.
Do.	1	3,200	Copper, wolfram and antimony.
Minbu	9	15,904·69	Petroleum.
Myingyan	16	35,440·79	Do.
Northern Shan States	2	4,160	Lead and allied ores.
Do. do.	1	5,120	Gold and allied metals.
Pakokku	3	6 blocks	Petroleum.
Prome	1	10,496	Do.
Salween	1	2,560	Galena.
Do.	1	1,600	Copper and galena.
Do.	1	6½ miles of the Bilin river.	Gold.
Southern Shan States	5	12,640	Lead, copper, etc.
Do. do.	1	2,560	All minerals (except oil.)
Do. do.	1	160	Gold and silver.
Do. do	1	1,600	Tungsten, tin, copper and associated minerals.
Tavoy	34	77,984·20	All minerals (except oil).
Do.	11	28,603·20	Tin, wolfram, gold, etc.
Thaton	1	1,600	Copper and galena.
Do.	1	3,200	Gold, copper, silver, iron and pyrites.
Do.	2	1,600 and 3½ miles of the Bilin river.	Gold.
Do.	1	2,560	Lead and silver.
Thayetmyo	13	31,756·80	Petroleum.

TABLE 31.—*Prospecting Licenses and Mining Leases granted in Burma during 1910*—concld.

DISTRICT.	1910.		
	No.	Area in acres.	Mineral.
Prospecting Licences.			
Toungoo	1	1,280	Gold, arsenic and galena.
Do.	1	1,440	Gold.
Upper Chhindwin	1	8,192	Petroleum.
Yamethin	1	4,960	Gold, silver, lead, copper and tin.
TOTAL	156	..	
Mining Leases.			
Akyab	1	568·91	Petroleum.
Myingyan	1	134·40	Do.
Pakokku	3	5 Blocks	Do.
TOTAL	5	..	

TABLE 32.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1910.*

Prospecting Licenses.

Balaghat	25	4,878	Manganese.
Do.	4	1,255	Manganese, copper, lead, etc.
Do.	1	148	Mica.
Do.	2	49	Red hematite.
Betul	1	91	Graphite.
Bhandara	25	4,906	Manganese.
Do.	1	53	Manganese, gold, silver, copper, lead and wolfram.
Do.	1	113	Mica.
Bilaspur	2	10,932	Coal.
Chanda	3	358	Manganese, lead, copper, iron, wolfram, zinc and galena.

TABLE 32.—*Prospecting Licenses and Mining Leases granted in the Central Provinces during 1910*—contd.

DISTRICT.	1910.		
	No.	Area in acres.	Mineral.
Prospecting Licenses.			
Chanda	1	2,383	Coal.
Do.	1	23	Felspar and steatite.
Chhindwara	3	11,914	Coal.
Do.	5	1,996	Manganese.
Drug	1	116	Gold, silver, copper and lead.
Hoshangabad	1	520	Coal and bauxite.
Jubbulpore	2	551	Manganese and iron.
Do.	1	421	Copper.
Do.	1	2,499	Coal and iron.
Do.	2	385	Steatite, talc, etc.
Do.	1	511	Bauxite.
Do.	1	633	Iron.
Nagpur	71	10,830	Manganese.
Do.	13	2,920	Manganese and other minerals.
Do.	2	821	Wolfram.
Raipur	1	222	Graphite.
Do.	1	355	Graphite, antimony, wolframite, copper, lead and galena.
Saugor	2	1,598	Manganese and iron.
Seoni	1	284	Felspar.
TOTAL	176	..	
Mining Leases.			
Balaghat	19	1,620	Manganese.
Bhandara	13	1,512	Do.
Chhindwara	2	368	Do.
Drug	1	36	Gold, silver, bauxite, cobalt, copper and lead.
Jubbulpore	1	141	Bauxite.
Do.	1	42	Manganese.
Nagpur	20	1,795	Do.
TOTAL	57	..	

TABLE 33.—*Prospecting Licenses and Mining Leases granted in Eastern Bengal and Assam during 1910.*

DISTRICT	1910.		
	No.	Area in acres.	Mineral.

Prospecting Licenses.

Chittagong	1	3,648	Petroleum.
Khasi and Jaintia Hills	2	6,400	Do.
Khasi and Jaintia Hills, Sylhet and Cachar.	1	31,360	Do.
TOTAL	4	..	

Mining Leases.

Lakhimpur	1	640	Coal, iron, slate and shales.
TOTAL	1	..	

TABLE 34.—*Prospecting Licenses and Mining Leases granted in Madras during 1910.*

Prospecting Licenses.

Bellary	1	319·09	Manganese.
Coimbatore	1	12·00	Corundum.
Cuddapah	1	640	Copper.
Do.	2	38·60	Barytes.
Kurnool	1	697·13	Diamonds.
Madura	1	2·21	Crystalline limestone.
Nellore	19	514·65	Mica.
Salem	1	36·78	Galena.
Do.	2	457·73	Magnesite and corundum.
Do.	1	91·52	Corundum.
Tinnevelly	1	30·84	Plumbago.
TOTAL	31	..	

TABLE 34.—*Prospecting Licenses and Mining Leases granted in Madras during 1910*—contd.

DISTRICT.	1910. No.	1910. Area in acres.	1910. Mineral.
Mining Leases.			
Bellary	1	1,132·80	Manganese.
Nellore	5	193·05	Mica.
Salem	2	385·21	Magnesite.
Do.	2	67·73	Mica.
TOTAL	10	..	

TABLE 35.—*Prospecting Licenses granted in the Punjab during 1910.*

Prospecting Licenses.

Jhelum	4	893·51	Coal.
Mianwali	3	16,960	Mineral oil.
TOTAL	7	..	

TABLE 36.—*Summary of Concessions granted in Government lands during the ten years 1901-1910.*

YEAR.	Mining and Prospecting Licenses.	Exploring Licenses.	TOTAL.
1901	89	15	104
1902	89	16	105
1903	84	16	100
1904	125	26	151
1905	145	44	189
1906	211	41	252
1907	539	61	600
1908	579	237	816
1909	550	143	693
1910	533	102	635

NOTE ON THE OCCURRENCE OF SAMARSKITE AND OTHER MINERALS IN THE NELLORE DISTRICT, MADRAS PRESIDENCY. BY G. H. TIPPER, M.A., F.G.S., *Geological Survey of India.* (With Plates 13 to 15.)

EXCEPT for one specimen said to have been found in the Tinnevelly district, samarskite is only known to occur in the Sankara (79° 47′, 14° 15′) mica mine, Rapur taluq, Nellore district, Madras. I examined this mine in April 1910 and again in January and February 1911, but, on account of the very imperfect methods of working and lack of really efficient pumping plant, it was impossible to make on either occasion a complete inspection of the whole mine. In spite of these drawbacks it was possible to examine the occurrence of the samarskite *in situ* and also to obtain other interesting minerals.

Like all the mica mines in Nellore, this is merely an open quarry in pegmatite, which here forms a large lenticular mass, the most prominent feature being a large boss of quartz.

The quarry runs in a roughly semicircular manner round this boss. It has been excavated in a series of compartments varying in depth from 15—50 feet with barriers between each and no attempt has been made to allow the water to drain off to the lowest point. Consequently it is almost impossible to get out all the water.

The segregation of the constituents of the pegmatite into large masses is very well marked. The large boss of quartz is surrounded almost completely by massive white felspar. The quartz is composed of interlocking grains and contains garnets and minute books of mica. The garnets are very ferriferrous and have in the weathered zone become limonite. The felspar is of two kinds, one extremely hard and massive, microcline, and the other somewhat softer, composed of parallel intergrowths of two felspars, the exact nature of which have not yet been determined. They are both often so cleaved that it is possible to split them into comparatively thin plates. Along cracks, weathering to a blue-grey tenacious clay has been considerable.

Both types of felspar are never quite pure, but contain mica varying in size from microscopic plates to books 2 or 3 inches in diameter. Strings of garnets are also common and occasionally nests of a mixture of hæmatite and magnetite. Where the massive felspar abuts on the quartz boss, mica of marketable size is abundant. The mica is of a dark-green colour in the mass and very often badly iron-stained. The impressions of the mica-books are very noticeable in the tunnels under the quartz from which the felspar has been removed.

In addition, there are other types of rocks. A coarse intergrowth of quartz and felspar is very noticeable. On the southern face at a depth of 20—30 feet are bands of rock composed of felspar, mica, and garnet. This may be fine grained or coarse and the two are generally distinct. In the coarse rock, the mica books are crumpled and usually have large garnets at the centre or occasionally a mixture of hæmatite and magnetite. The felspar is in fairly large masses and may be white or pinkish brown in colour. So far as I have been able to determine, the samarskite invariably occurs in the rock with pinkish brown felspar and never in that with the white. Further, it is never idiomorphic but occurs as irregular angular masses embedded in the felspar, sometimes wholly. sometimes only partly, with small books of mica attached to it. A complete search through all the material available (about 3 tons) at the mine failed to bring to ligh a single piece showing crystalline outlines. The samarskite masses vary very considerably in size from almost minute fragments up to masses weighing as much as 200℔. They are very often surrounded by an aureole of decomposed felspar.

There are no indications of a continuous vein of the mineral, neither is it possible to form any estimate of the amount present in the rock; but very often the finding of one mass of the mineral leads to the discovery of another. The rock in which the mineral occurs is part of the pegmatite mass, but it is quite impossible to say whether it is in any way continuous in depth.

As already remarked, no crystals of samarskite have yet been discovered. It is in angular masses, which are often slightly weathered along numerous cracks. A fresh surface reveals a splendent black lustre and a typically conchoidal fracture. It is quite opaque, even in the thinnest slices. The specific gravity varies from 5·4—5·7, according to the purity of the material. A qualitative analysis by the late Mr. Blyth showed it to be a niobate and tantalate of the cerium and yttrium earths and uranyl with iron and calcium. The uranium content varies considerably. The mineral is strongly radioactive. As it seemed possible that the minerals with which the samarskite is associated contained uranium they were carefully tested chemically but without any result.

Beside the samarskite observed *in situ*, a few small weathered fragments were obtained from the gravel cap above the pegmatite on the north and south of the mine. These were situated at no great distance from the position in which the first piece of samarskite was noticed *in situ*. Search on the slope to the small nullah south of the mine gave no result. The mineral is now so well-known in the district that it is improbable that any large quantity was exposed above the surface and carried to any distance or I feel sure that it would have been noticed.

In addition to the samarskite two other uranium-bearing minerals occur. One of these resembles allanite in its mode of occurrence. It occurs as long black crystals resembling tourmaline in the garnet-mica-felspar-rock, surrounded by a translucent brownish epidote-like mineral. The mineral is dull-black, opaque, and has a specific gravity of 3·05 at 15°C. A quantitative analysis shows it to differ from allanite in two important particulars:—(1) in the presence of 17·8($\frac{3}{8}$) per cent. of Nb_2O_5[1] and (2) in containing 5·39 per cent. of U_3O_8. It contains in addition 19·8 per cent. of the cerium earths. Owing to an unfortunate series of accidents none of the analyses started was completed but qualitative tests show that, beside the above constituents, it contains iron, manganese, calcium, alkalies, and a little water.

The third mineral has been identified as a hydrated variety of zircon containing uranium. It particularly resembles that variety described as cyrtolite. It has been found (1) in association with the samarskite and (2) abundantly in the decomposed felspar abutting on the quartz boss. It occurs in large sheaf-like aggregates of crystals terminated by crystal-faces. These faces are often strongly curved as in the original cyrtolite. When the faces are sharp, they give angles corresponding to those of true zircon. The mineral is pale grey-brown in colour. Microscopic examination shows that it has undergone a very considerable amount of alteration. It has a specific gravity of 4·09 at 15°C. This increases after heating. A complete analysis gave the following result :—

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[1] The presence of niobic oxide in the residue left after treatment of the silica with hydrofluoric acid was proved by the formation of the niobium blue with zinc and sulphuric acid. Further, treatment with acid potassium fluoride in the presence of hydrofluoric acid failed to give the characteristic needles of the double fluoride of potassium and tantalum but gave abundant plates of the double niobium fluoride.

ZrO_2	62·3
SiO_2	26·06
Fe_2O_3	5·41
Ce_2O_3 etc.	traces
MnO	,,
U_3O_8	2·42
H_2O	3·3
	99·49

The ferric oxide certainly contained traces of zirconia. The zirconia was estimated by precipitation by means of sulphurous acid from a neutral solution. In this way precipitation is probably never quite complete or rather, if carried to completion, contamination by iron is almost certain to happen. The uranium was estimated by first of all separating the elements of the third group (after getting rid of the zirconia) by means of ammonium sulphide in the presence of ammonium carbonate in which uranium salts are soluble. It was then precipitated as ammonium uranate and weighed as U_3O_8. As alumina is slightly soluble in similar circumstances, any traces of Al_2O_3 have been calculated as U_3O_8.

The powdered mineral is attacked by strong hydrochloric acid, the whole of the iron and some zirconia going into solution. About 15 per cent. is dissolved by heating for one hour.

From the analysis the formula for the mineral corresponds fairly closely to $2ZrSiO_4.H_2O$.

LIST OF PLATES.

PLATE 13.—Sankara mine looking N. W.

PLATE 14.—Sankara mica mine showing the position of the samarskite.

PLATE 15.—Plan of Sankara mica mine. Scale 1″ = 50 feet.

COAL IN THE NAMCHIK VALLEY, UPPER ASSAM.

BY E. H. PASCOE, M.A., B.SC. *Assistant Superintendent, Geological Survey of India.* (With Plate 16.)

AT the beginning of April, 1911, some seams of coal of some importance, of which I can find no published account, unless the three beds observed by Mallet are the continuation of some of them (see below), were discovered by Mr. G. C. Webster, Colliery Manager of the Margherita Coal-fields, and myself, while on a visit to the mouth of the Namchik River, a tributary on the left bank of the Dihing. The locality is three long days' journey by boat up the latter river from Margherita; "dugouts" for this purpose can be obtained from the Phakial village six miles above Margherita.

The seams were found in a small tributary of the Namchik with a very inconspicuous outlet, some half a mile above its mouth. About 60 feet of coal is exposed here in 5 groups of seams which I have lettered on the sketch-map A, B, C, D, and E (Pl. 16). The following are particulars of the seams in descending order, the highest being nearest to the mouth of the stream, and perhaps corresponding to the two outcrops of coal and carbonaceous shale seen on both sides of the Namchik itself further down:—

		Ft.	ins.	Ft.	ins.	
	Grey clay.					
A	Coal (shaley)	0	9	...		
	Clay	...		2	6	
	Coal	0	6	..		Dip 65°; 10°E. of S.
	Sandstone and clay			about 63		
B	Coal	2	3	...		
	Clay	...		3	3	
	Coal	5	0	...		
	Clay	...		3	8	Dip 55°;
	Coal	5	0	...		8° W. of S.
	Sandstone and clay	...		27	0	Dip 55°; S.
C	Coal	2	6	...		
	Clay			2	6	Dip 55°;
	Coal	1	9	...		5°E. of S.
	Clay	...		1	4	
	Coal	5	0	...		Dip 59°;
	Clay			4	4	11° E. of S.
	Coal	5	6	...		

		Ft.	ins.	Ft.	ins.	
	Sandstone and clay	...		138	0	Dip 42°; 8° E. of S.
D	Coal	12	0	...		
	Fireclay	...		2	0	Dip 40-45°; 5-10° E. of S.
	Coal	4	3	...		
	Clay	...		1	9	
	Coal	2	3	...		
	Clay	...		0	6	
	Coal	3	0	...		Dip 10° E. of S.
	Sandstone and clay	...		29	0	
E	Coal (stoney and poor in quality).	5	6	...		
	Coal (good quality)	2	6	...		
	Clay	...		3	8	
	Coal	1	6	...		
	Clay and sand	...		13	6	
	Coal	1	6	...		
	Clay	...				Dip 42°; S.
		60	9	296	0	
	TOTAL STRATA	356 ft. 9 ins.				

Except where otherwise stated, the coal is of excellent quality, and probably corresponds in horizon to that at Margherita and Ledo, which it resembles. The strata evidently belong to the Tertiary "Coal Measures" of Assam. The total thickness of coal measured was 60 feet, of which 5 or 6 feet was of poor quality; all this occurs within a thickness of about 360 feet of strata. The seams probably form part of the southern limb of an anticline trending nearly due east and west. The dip of the highest beds is as much as 65°, but further north, nearer the anticlinal crest, which is probably situated within half a mile of the Dihing, it sinks to 55°, 45° and 42°. The direction of dip is from 5-10° E. of S., swinging round slightly in one case to 8° W. of S.

Unfortunately the ground does not rise to any height in the immediate neighbourhood, the Naga field marked on the map, which occurs on the highest point between the small stream and the Dihing, being perhaps 100 to 150 feet above the level of the river. It is therefore doubtful how much of the coal, at any rate in the immediate vicinity of the tributary, is above water-level and could be worked without haulage and pumping. Only one seam of coal, and that a poor one, is exposed in the Namchik itself, but the thick jungle and heavy soil deposit would be quite sufficient to conceal outcrops. It is quite possible that additional seams will be found below those enumerated, but there was not time to examine other stream-courses extending further northwards and more deeply into the anticline. "Three thick beds of sound, good coal," one of them 8 feet thick, were observed by Medlicott in 1865, "in a small stream flowing northwards shortly before the ridge is interrupted by the gorge of the Namchik."[1] These beds may possibly be the continuation of some of the above seams on the other side of the Namchik, but I am more inclined to think that Medlicott's section is further to the south and represents higher horizons. Mr. La Touche also found two seams of coal, one 3 feet, the other at least 6 feet thick, 14 miles E. N. E. of the junction of the Namchik and Dihing, in a small stream entering the latter river opposite Luan.[2]

The locality is only 18 miles in a straight line from Ledo, the terminus of the Dibru-Sadiya Railway: about 30 miles of light railway would, I believe, be required to connect the two places. It is not improbable that an oil-field also will be proved to exist on the other side of the Namchik, so that it is appropriate to draw attention to the fact that this area occurs on one of the possible railway routes connecting India with Burma.

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[1] *Mem. Geol. Sur. Ind.*, vol. IV, p. 399.

[2] *Rec. Geol. Sur. Ind.*, vol. XIX, p. 112.

EXPLANATION OF PLATE 16.

Sketch-map of coal outcrops in a tributary to the Namchik River Upper Assam. Scale 1" = 100 feet.

MISCELLANEOUS NOTES.

The condition of Barren Island in 1846, as described by Officers of the Danish Corvette *Galathea.*

IN the annotated summary of earlier accounts, given by Dr. V. Ball in his paper on Barren Island, as he saw it in 1873, the author states that 'In 1846 the island appears to have been visited by the Danish Corvette *Galathea*, but the only record of the fact which I know of is an inscription on a rock on the island—" GALATHEA, 1846." '[1] I saw the inscription myself in 1884, but was not in possession of any further information connected with it when writing respecting the volcano.[2] Some time ago, however, I applied to the Secretary of the Royal Danish Geographical Society at Copenhagen, asking if he could throw any light on the question, and in reply he very kindly sent me a list of six manuscript and printed works relating to the *Galathea* expedition round the world. The only one of these, however, that is relevant to the present question is the general account of the voyage by Steen Bille, under the title " Beretning om Corvetten Galathea's Reise omkring Jorden. 1845, 46 og 47. Ved Steen Bille, chef for expeditionen. Kjobenhavn. I, 1849; II, 1850; III, 1851." The Geographical Society (London) possesses a complete copy, while the British Museum library has the first two volumes, together with a German translation of the same, entitled " Steen Billes Bericht über die Reise der Corvette Galathea um die Welt in den Jahren, 1845, 46 und 47. Aus dem Dänischen übersetzt, und theilweise bearbeitet von W. v. Rosen, Mitarbeiter am Original. Kopenhagen. Leipzig. 1852."

It appears from the German edition, and the accompanying chart of the course taken by the *Galathea*, that after leaving Calcutta, and passing Narcondam at a distance of 8 or 9 nautical miles, Barren Island was reached on the evening of January, the 3rd, 1846. The next day was spent in various explorations on shore, and during the same evening the Corvette made sail for the Nicobars. Seven pages (I, 173—179) are devoted to Barren Island, but it is scarcely necessary to give a translation in full, the general description of the island as a whole being necessarily very similar to that of other visitants during the last hundred years. The following extracts include everything of interest relating to the condition of the volcano in respect to activity:—

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[1] *Rec. Geol. Surv. India*, VI, 83, (1873).

[2] *Mem. Geol. Surv. India*, XXI, 251, (1885); *Rec. Geol. Surv. India*, XX, 48, (1887); XXVIII. 22 and 34, (1895).

"From the summit" (of the inner cone) "rose a continuous white smoke, which, as illuminated with a reddish light by the setting sun, formed a column against the beautiful dark blue sky. * * * We succeeded in discovering the right, and as it subsequently proved, the only landing place in the island. A small reef of rock forms here a boat-harbour as it were; the shore is low and accessible at ebb tide. A thermal spring flows out here, the water of which was so hot that the men, who sprang on the beach in order to draw up the boat, scalded themselves therein. It was the only water that we could find on the island. * * * The highest parts of the cone[1] were towards the N. W. and W. Sulphurous vapours, which rose from innumerable crevices, had covered almost the entire summit with small, slender, yellow-green crystals, while here and there on the lava a loose, friable, white substance lay, which, when one took it up, crumbled between the fingers. The suffocating sulphurous vapours oppressed us, and the rock under our feet, as we descended into the crater, was burning hot in places. The crater was about 40 feet deep, the floor, which was 15 or 16 feet in diameter, being filled with a red-yellow sand in which we scratched 'Galathea, 4-1-1846' with our sticks, putting a cross of stones over the inscription. On the south wall of the crater a spring, one cannot say ran, but dripped down, giving rise to a charming bed of moss and very small ferns, which formed a wonderful contrast to the remainder of the bare ash-cone. * * * On a flat surface of granite close to our tent, I had 'Galathea, 1846' carved, and half-buried here a bottle containing a paper, explaining to later visitors, in English, in what condition we found the crater, when we were here, and how we carved a record of the water-level (Merkmal des Wasserstandes; Danish Vandstandsmærke) in the rock close to the spring. At the same time I had placed a coronation medal therein, which I offered to the finder as a memorial of the *Galathea's* visit. The document was signed by all present."

The "yellow-green" crystals, mentioned above, were obviously the deposits of native sulphur that have been described by several observers.[2] The colour of a specimen given to me by Dr. Ball, who collected it in 1873, and of another I obtained 11 years later and now in my possession, is slightly greenish yellow, especially on the original crystalline surface. In some Vesuvian specimens the colour approaches yellowish-green. The white friable substance alluded to may have been basic aluminium sulphate.[1] Except perhaps for a short time after heavy rain, a spring, in the more ordinary sense of the term, would be impossible close to the summit of the cone; that noticed by von Rosen,[2] which was seemingly perennial, doubtless owed its existence to the condensation of steam issuing from crevices in the rock.

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[1] *I.e.*, the highest parts of the crater rim of the inner, or central, cone.—F. R. M.

[2] *Rec. Geol. Surv. India*, VI, 88, (1873); XXVIII, 34, (1895); *Mem. Geol. Surv. India*, XXI, 278, (1885).

A word should perhaps be said respecting the rock on which is inscribed "Galathea, 1846," as otherwise the account might lead to misunderstanding. Although blocks of non-volcanic rock are in some cases ejected by volcanoes, one of the best known examples being the dolomitic blocks on Mount Somma, such have never been noticed on Barren Island, whether of granite or of other non-volcanic material. More than a quarter of a century has passed since I was there, and I do not now recollect what the inscribed rock actually is, but the fact that there is no allusion to it in my memoir leads me to the conclusion that the inscription is on a block of lava of some ordinary type. Dr. Ball likewise is silent on this point.

So far as I am aware, the bottle left by the *Galathea* party has never attracted attention since its partial burial. As no one subsequently landing on the island appears to have been acquainted with Steen Bille's account, it is fairly certain that the bottle has never been looked for, and its casual discovery may have been prevented by overgrowing vegetation, or otherwise. The next visitors would do well to search for it, though, unless the bottle was provided with a well-fitting glass stopper, one cannot hope very confidently to find the enclosed paper in a legible condition. The document may include exact information as to the object of the water-level-mark (which likewise seems to have escaped observation since it was made). I do not believe that it could have had anything to do with the hot spring, and therefore it seems clear that it must have recorded the tide-level, but what phase of the tide Steen Bille's published account does not say. High water level seems the most probable. The mark may have been intended as a datum-line, to aid later observers in detecting any elevation or depression of the island subsequent to the *Galathea's* visit. Should the mark be found, it ought to be renovated, if in bad condition through so many years' exposure to sea and weather.

[F. R. MALLET.]

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[1] *Mem.*, *l.c.*, 269.

[2] The ascent of the cone was made by von Rosen and Kjellerup. *Cf. Mem.*, *lc.*, 267, 268.

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THE PEGU-EOCENE SUCCESSION IN THE MINBU DISTRICT NEAR NGAPE. BY G. DE P. COTTER, B.A. (DUB.), F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 17 to 21.)

Introduction.

I VISITED the Ngape township of the Minbu district in December 1909 and January 1910, and in the following April, Mr. Sethu Rama Rau, Sub-Assistant, Geological Survey, made collections of fossils from the same area.

The fossils are of Nari and Khirthar age, and the area has been already alluded to in the following papers :—

(1) Noetling :—Note on the Occurrence of *Velates schmideliana* Chemn. and *Provelates grandis* Sow. *sp.* in the Tertiary Formation of India and Burma.—*Rec. Geol. Sur. Ind.*, XXVII, p. 103.

(2) Hayden :—Steatite Mines, Minbu district.—*Rec. Geol. Sur. Ind.*, XXIX, p. 71.

(3) L. V. Dalton :—Geology of Burma, *Quart. Jour. Geol. Soc.*, LXIV, p. 604.

The Irrawaddy Series.

The Irrawaddy series, the base of which is seen near the villages of Aingma and Kokkyi, contains less fossilised wood than the better known areas of the oil-fields, and is composed mainly of gravels and soft conglomerates made up of water-worn quartzite pebbles in a ferruginous earth, generally distinguishable from the Plateau Gravel by the dip. These beds, when disintegrated and redeposited, form beds which I am unable to distinguish from the Plateau Gravel or Red Silt.

Hayden, in his description of the "Chin Shales" (Theobald's "Axials")[1] which underlie the Eocene and are exposed on the main chain of the Arakan Yoma, makes the following remark, which suggests an explanation of the presence of these large deposits of quartzite pebbles in the Irrawaddy series,—"Another very interesting feature of the rocks here" (*i.e.*, in the Yoma hills west of Pa-aing, a village about 15 miles north-west of Ngape) "is formed by numerous strings of quartzite pebbles and boulders enclosed in these shales: these enclosures are of all size and range from blocks weighing several tons down to fragments an inch or so in length." Such quartz pebbles are found occasionally forming conglomerates in both the Pegu and Eocene series, but they are typical of the Irrawaddy series in the Minbu area; this is only what might be expected, since the greatest upheaval and consequent rapid denudation of the Yomas took place after the close of the Pegu epoch.

The Pegu Series.

The Pegu series are marine and estuarine deposits, containing the usual assemblage of fossils which are in the middle of the series most frequently characteristic of the *laminaria* zone.

It is not proposed in this paper to describe the fauna of the Pegu beds, except those of their basal division, the "Sitsayan Shales," but it is worth noting that as one traces the series northwards, there are evidences of shallower and shallower water; thus fossil wood is rare but present in the north of the Minbu district near Ngahlaingdwin (Lat. 20° 41′; Long. 94° 22½′), while in the Pakokku district it is abundant in the Pegu series, and the sandstones at times simulate the current-bedded Irrawaddy series.

The Sitsayan Shaels.

Towards the base of the Pegu series there is an easily recognisable zone of clays, blue grey in colour, containing a subordinate bed of grey earthy limestone—marked "C" on the map—which apparently dies out south of Padaung village. Northwards we have not followed it up beyond Payaywa village. The zone of clays is perhaps 1,300—1,500 feet thick, the limestone bed being in the upper part, and of a thickness of 35 feet near Thanbayagaing village (locality C. 3). About

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[1] Theobald, *Mem. Geol. Surv. Ind.*, Vol. X, Art. 3, p. 315.

70 feet above the limestone at this locality the following fossils were found in the shale :—

Cancellaria martiniana Noetl.
Conus protofurvus Noetl.
Turritella angulata Sow.
Solarium sp.
Cytherea sp.

The limestone bed contains the following both in this and other exposures :—

Lepidocyclina elephantina Munier-Chalmas. (=*Orbitolites Mantelli* Cart. var. *theobaldi* Cart.)
Heterostegina sp.
Pecten (*s. str.*) *sp. cf. subarcuatus* Tourn.

In the shales below the limestone at "C. 3" the following species were found :—

Fasciolaria nodulosa Sow.
Conus literatus Linné.
Cancellaria martiniana Noetl.
Tellina sp. cf. protocandida Noetl.
„ „ *cf. hilli* Noetl.
Turritella angulata Sow.
Strioterebrum sp.
Pleurotoma cf. karenaica Noetl.
Ficula sp.
Genota sp. cf. irravadica Noetl.
Dione sp.
Crab claws.

and below the limestone at "C. 2" a species of *Schizaster* resembling *S. baluchistanensis* d'Arch. These fossils are characteristic of a Nari age, and most probably Upper Nari, corresponding with the Lower Aquitanian of Europe.

I obtained from a villager of Thanbayagaing some specimens of *Lucina globulosa* Desh. which he brought at my request from a locality which he stated was north-west of Payaywa, and which must lie below the "C" horizon. The Headman of the village also handed me a specimen of the same species, which he stated had been found in the Man stream close to his village. Owing to pressure of other work I was unable to visit the locality myself. These shales from their stratigraphical position and general facies agreeing with Theobald's description,[1] are most probably equivalent to the Sitsayan shales of the Prome district, although the country lying between the two areas has not been geologically mapped as yet, and the question must remain undecided until an examination has been made.

The Sitsayan shales, if we may provisionally so describe the beds alluded to above, are underlain by a series of massive sandstones alternating with shale beds, containing in the upper part (Beds D, E, and F) a Nari, and in the lower beds (Beds G, H, I, J) a Khirthar fauna. There appears to be parallelism of strike and dip between the two series, but the absence of fossils belonging to the Upper Khirthar, or to the Tongrian and Bartonian periods seems to hint at the possibility of an unconformity between the Nari beds and the Eocene.

If such unconformity exists, it may be compared to that between the Nari and the Khirthar in North-West India. Stuart[2] also has recently described an unconformity below the Sitsayan shales in the Prome area. I am unable to do more than draw the boundary between the Pegus and the Eocene by an approximate line, since there does not appear to be any lithological difference between the rocks of Nari age and those of the Eocene near the boundary; I have therefore been entirely dependent upon fossil evidence.

The following is a list of the species from beds D, E and F, which I have referred to as being of Nari age :—

The bed marked "D" on the map contains a *Vicarya* allied to, but apparently differing in ornamentation from, *V. verneuili* d'Arch., fragments of *Ostrœa*, some large *Ampullinœ*, and *Cardita sp. cf. mutabilis.*

Bed E contains :—

Turritella sp. cf. halœnsis Coss.
Corbula subexarata d'Arch.
Donax sp.
Cardita sp.

and others, not yet identified.

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[1] Theobald. *Mem. Geol. Surv. Ind.*, Vol. X, Art. 3, p. 81.

[2] *Rec. Geol. Surv. Ind.*, XXXVIII, p. 262.

Bed F contains:—

Cardita sp. cf. keyserlingi d'A. & H.
Venus granosa Sow.
Turbo sp. cf. pendjabensis d'A. & H.
Vermetus javanus Martin.
Surcula sp. cf. voyseyi d'A. & H.
Trochus sp. cf. cognatus Sow.
Strombus sp.
Natica sp.
Ficula sp.
Cassis sp.

From the fossil-bed between the 27th and 28th mile-stones on the Minbu-Ngape road I obtained an echinoid too damaged for accurate determination, but very closely resembling *Euspatangus rostratus* D'Arch., and *Tellina sp. cf. protocandida* Noetl. The former species is of Nari age.[1]

South-west of Thanbayagaing, above the "G" horizon (which is of middle Khirthar age, and will be described below) a bed of badly preserved echinoids occurs, the prevailing genus being *Clypeaster*. My colleague Dr. G. E. Pilgrim has examined these specimens and recognises them as of Nari age. This locality being in fairly close proximity to the "G 2" locality (which contains *Velates schmideliana*, and is of middle Khirthar age) and being stratigraphically just above it, is fairly strong evidence in favour of an unconformity between the Pegus and the Eocene, since there is hardly room for rocks of Upper Khirthar or Bartonian ages to exist between the two horizons.

At the fossil-bed (see map) half way between "G 2" and Padaung village the following were found:—

Oliva sp.
Ficula sp.
Solarium sp.
Cypræa sp. cf. obesa Desh.
Tellina sp.

The fossils from this bed give no definite evidence of age. A loose fragment of rock containing *Operculina* was found near this bed on the hill-side.

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[1] Vredenburg: Tertiary System in Sind, *Rec. Geol. Surv. Ind.*, XXXIV, p. 189.

Fauna of the Eocene.

The fossil-bed at the deserted village of Kyet-u-bok—one of the highest beds of the Eocene—yields an interesting fauna, partly described by Dalton. I obtained the following specimens :—

Orthophragmina omphalus Fritsch.
Nummulites beaumonti d'Arch.
Gypsina sp.
Campanile sp. cf. giganteum Lamark.
Meretrix sp. cf. parisiensis Desh.
Conus brevis Sow.
Ampullina sp. cf. sindiensis Coss. & Piss.
Cardium ambiguum Sow.
Ficula sp.

The above fauna is probably middle Khirthar in age.

The bed marked "G" is a fairly constant horizon containing at the top a limestone full of *Operculina*. It contains :—

At G 2 :—

Velates schmideliana Chemn.
Cardium ambiguum Sow.
Conus literatus Linn.
" *sp. cf. substriatellus* H. Wood.[1]
Corbula subexarata d'Arch.
Venus subovalis d'Arch.
Cypræa elegans Defr.
Volutospina sykesi d'Arch.
Voluta jugosa Sow.
Pleurotoma sp.
Vulsella sp.
Siliquaria sp.

At G 3 the following :—

Cardium ambiguum Sow.
Rimella cf. prestwichi d'A. & H.
Turritella sp. cf. heberti d'A. & H.
Corbula subexarata d'Arch.
Cassis sp.
Conus sp.
Triton sp.
Tellina sp.

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[1] Woodward : Foss. shells from Sumatra, *Geol. Mag.*, 1879, Pl. XII, f. 2.—*Paleontograph. Supp.* III, Lief. 8-11, p. 75, Pl. VI, 8-9.

Below the "G" horizon near Peinhnebin beds of impure coal occur and there are two oil-seepages at the spots marked upon the map. I have heard that the oil-sand outcrops again to the north-west, but it has not yet been examined. The bed "H" north of Chaungbyu village contains:

Cardita mutabilis d'A. & H.
Corbula sp. cf. harpa d'A. & H.
Rimella sp. cf. prestwichi d'A. & H.
Mytilus sp. cf. denticulatus Lmk. (=*heberti* Desh.).
Cardium sp.
Corbula sp.
Arca sp.
Ostræa sp.
Voluta sp.
Oliva sp.
Donax sp.
Cytheræa sp.

The bed "I" contains *Nummulites vredenburgi* Prever, a form characteristic of the lower division of the middle Khirthar.

The bed "J" at Thakutpin village contains:—

Turritella sp. cf. heberti d'A. & H.
Cardium sp.
Solarium sp.
Corbula sp.
Natica sp.

Below this horizon fossil-beds occur on the road from Pyawbwe to Sinchidaing at the spots marked on the map, but they all contain fossils too fragmentary for identification.

Ngape Area.

The beds immediately underlying "J" are obscured by the alluvium of the Man River. At Sabagyidan village, vertical and contorted beds are seen in the river-section, and it is probable that a fault should be marked here. Whether there is reduplication of the rocks exposed east of Sabagyidan or not, I am unable to say, but if this is not the case, the immense thickness of the Eocene is a difficult matter to explain. No fossils were found either by Hayden or myself in the rocks near Ngape on the south-west side of the alluvial belt. Hayden, however, found fossils, ½ mile west of Shauktaung: I quote the passage from his paper. "As the road approaches Ngape, the sandstones become unfossiliferous, and between that place and Shauktaung, the beds appear to contain no recognisable organic remains. At about half a mile west of Shauktaung, the sandstones are underlain by thick beds of very finely laminated shale with occasional carbonaceous bands. In these shales occur at first narrow bands of sandstone, and beneath these a thick bed of grey limestone with nummulites in places. As a rule, however, in this neighbourhood, the limestones have been altered to such an extent by outbursts of dark green serpentine that the fossils are not recognisable."

"Chin Shales."

Beneath these beds Hayden places the boundary of the "Chin Shales" of Dr. Noetling. A misunderstanding as to the meaning of this term has arisen in Dalton's paper above quoted (p. 618). To explain this, it is necessary to refer to Theobald's original statement (*op. cit.* p. 100). Theobald there stated that the thickness of a particular section of Eocene rocks in a stream near Thambula, Thayetmyo district, was 1,223 feet, but he obviously did not intend this to be taken as the thickness of the whole Eocene, since on page 104 he speaks of the "astonishing thickness of this early tertiary group." Dr. Noetling, however, (Pal. Ind., New Ser., I, 3, p. 6) erroneously quotes these figures as representing the whole thickness of the Eocene. Dalton does not refer to Hayden's paper, where the term Chin Shales is clearly defined, but in discussing the section of Eocene beds in the Minbu area includes the topmost 1,223 feet in "the Bassein division of the Eocene," and proceeds as follows:—"This leaves 3,000 feet according to Dr. Noetling for the Chin Division, the age of which is not known; but part of it belongs to Theobald's 'Axial series' of the sub-division of which something has already been said. It is suggested therefore, that, to accord with our later knowledge, the name of the Chin Division be dropped." There is now no reason for dropping the term "Chin Shales" to represent the pre-Eocene rocks of this area, when it is remembered that Dalton's argument rests on the error that the "Bassein series" is only 1,223 feet thick. What Dalton calls Chin Division in this paragraph are in reality lower horizons of the Eocene; the real Chin Shales lie to the west near Shauktaung village.[1]

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[1] *Note.*—It is very possible that the Chin Shales represent a large thickness of Mesozoic rocks, of which the upper beds are of Cretaceous age, *vide* note on the Trias of Lower Burma by Mr. Tipper (*Rec. Geol. Surv. Ind.* XXXV, p. 119). The *Cardita beaumonti* locality lies in the Thayetmyo district, about 50 miles to the south of the Ngape area, but judging by the strike of the rocks, there is reason to hope that further mapping will prove that the Chin Shales described by Hayden are identical with these Thayetmyo beds.

Lower Eocene.

To return to our remarks on the Eocene beds, the rocks at Paunggyi near Ngape are steeply dipping beds of sandstone and shale, and are underlain on the west by grits and conglomerates of massive appearance, which form the hill-range at the north-east foot of which Paunggyi village lies. They appear quite unlike any of the rocks seen east of the fault at Sabagyidan; from Hayden's discovery of nummulites west of Shauktaung, we may regard them as probably Eocene, although this point is open to question, and cannot be settled till the Shauktaung fossil-bed has been examined, and till it is known whether this bed is really lower in the series than the beds near Ngape, or has been faulted down. The rocks may perhaps be compared to Theobald's description of the section in the Hlwa stream, of the lower Eocene (*op. cit.*, p. 103, *sqq.*); those rocks also contain carbonaceous markings and massive sandstones at the top of the series. For these reasons I refer them temporarily to the Lower Eocene.

Thickness of Eocene.

The outcrop of the Upper Eocene or Khirthar from its top down to the probable fault at Sabagyidan village is about 1½ miles thick. Taking the average dip at about 40°, we get a thickness of over 5,000 feet for the Upper Eocene. The thickness of the whole Eocene is doubtless much greater, but as I have said, it is doubtful whether there may not be reduplication in part of the area between Sabagyidan and Shauktaung. Dalton gives a thickness of 8,125 feet, which he says is the least possible. He describes an anticline, the crest of which runs north-west near Thabyemyaung (Thayetmyo district) and considers that this fold passes through Sabagyidan. I examined the section in the Man stream at Sabagyidan, but no trace of an anticlinal crest was visible, the beds being vertical and contorted. But the decision of the question of the thickness of the Eocene must also be left till the areas to the south and north have been worked out.

Thickness of Pegus.

The thickness of the Pegus, as determined by a section through Pyawbwe, appears to be over twelve thousand feet. From the "C" bed near Thanbayagaing to the "G" bed, there is a thickness of over four thousand feet of strata, which represent the Nari facies of the Pegu series. It is probable that the thickness of the Pegus varies considerably, owing to the unconformity above and to that which probably exists also below between them and the Eocene.

Unconformities.

Of the two unconformities known in Upper Burma, the highest—that between the Irrawaddys and the Pegus—is apparently slight, and has been discussed in previous papers; the age of this unconformity is probably Pontian, since, according to Pilgrim, the basal beds of the Irrawaddys are of middle Siwalik or Pontian age. It thus corresponds to some extent with Vredenburg's "second phase of Himalayan upheaval" mentioned in his "Summary of the Geology of India."

The evidence for the unconformity between the Pegus and the Eocene is, in this area, negative evidence, that is to say, amongst a fairly large collection of fossils, none of Upper Khirthar or Bartonian age have been found, and the fossils of Nari and middle Khirthar age have been found in horizons not far separated from one another. I cannot regard this evidence as conclusive, but rather as suggestive. It would certainly be interesting to find that an unconformity existed in Burma similar to that between the Naris and Khirthars in North-West India, and corresponding with Vredenburg's "first phase of Himalayan upheaval," but the theory must still be regarded as uncertain.

There are two oil horizons, one above the Kyet-u-bok bed and probably of Nari age; the second at Peinhnebin is Lutetian or middle Khirthar, and is associated with coal. Neither of these outcrops is of economic value owing to the absence of an anticlinal crest. Limestone is worked at Kyauko, Thanbayagaing and Sabagyidan.

PALÆONTOLOGY.

IT will have been observed that many of the species from the shales above and below the "C" horizon are also found in the higher parts of the Pegu beds.[1]

Nari Fossils. (Sitsayan Shales.)

The fossils which may be noticed here are *Heterostegina sp.*, *Lepidocyclina elephantina*, *Pecten sp.*, *Schizaster sp.*, and *Lucina globulosa.*

(1) *Heterostegina sp.* (Pl. 17, figs. 1, 2, 3).—The test is oval in shape, measuring in the largest specimen 28·5 mm. by 25 mm. The thickness does not exceed 1·5 mm. There are about three whorls divided into long narrow chambers by primary septa; these are again subdivided into secondary chamberlets by secondary septa. The length of the largest chamberlets of the last whorl is nearly 0·5 mm. The septal walls are about two-thirds the breadth of the cells.

In size the species resembles *Spiroclypeus orbitoideus* Douv. from the Aquitanian of Borneo,[2] but the whorls do not embrace in the adult form, and our species appears to be a true *Heterostegina.* It must therefore be one of the largest known species. The button which marks the central whorl is flat and placed near the margin, not centrally as in *Spiroclypeus. Heterosteginæ* of from 5 to 10 mm. diameter are found in the Lower Aquitanian of Borneo,[3] and large forms are mentioned by Vredenburg, associated with *Lepidocyclina* in Baluchistan.[4]

The microphotograph on Pl. 20, fig. 1, is taken from a *Heterostegina* measuring 7·5 mm. in length, and associated in the limestone with the large forms described above. I am unable to say whether it is a different species from that described or a young individual. It differs in the shape of the cells, which are broader, but it is also noticeable in the large form that the earlier cells are broader than those of the last whorl.

[1] *Pal. Ind.*, New Ser. 1, pt. 3, *passim.*

[2] Douvillé, *Bull. de la Soc. Geol. de France*, 4th ser., V, 1905, p. 458 *sqq.*

[3] Douvillé, *op. cit.*

[4] *Rec. Geol. Surv. Ind.*, XXXV, p. 65.

(2) *Lepidocyclina mantelli* Cart. var. *theobaldi* Cart. (Pl. 17, fig. 4).—This form is also known under the name of *Orbitolites mantelli* Cart. var. *theobaldi* Cart., but Vredenburg regards it as probably identical with *L. elephantina* Munier-Chalmas.[1] Carter[2] has given a full description of the species; his specimens were obtained from Peitating (*sic*=Peikthalein) village 6 miles south of Thayetmyo.

Oppenheim[3] places *L. elephantina* in the lower Aquitanian of Schio, and in the table on page 31 of Lemoine and Douvillé's monograph[4] on the genus, it also characterises the lower Aquitanian of Vicentin. The largest of our specimens measures 8 centimetres.

(3) *Pecten* (*s. str.*) *sp.* (Pl. 17, figs. 5, 6, 7).—It is to be regretted that MM. Depéret and Roman in their monograph on the *Pectenides*[5] have not included the older Tertiary forms; of their six groups of the sub-genus *Pecten*, this form is most closely related to the group of *P. subarcuatus* Tournouër.[6]

The height is 34 mm., the breadth 37 mm. The right valve is swollen and ornamented with 15 rounded equal ribs separated by furrows slightly wider than the ribs. The left valve is similarly ornamented and is distinctly concave.

(4) *Schizaster sp.* (Pl. 18, figs. 1, 2, 3).—This form presents a distinct resemblance to *S. baluchistanensis* d'Arch.; the chief points of difference between it and the variety described by Duncan and Sladen[7] are:—

(*a*) The antero-lateral petals show about 26 rows of pores; owing to the bad state of preservation, I am uncertain of the exact number; and the posterior petals show 20-21 rows. Duncan and Sladen's form shows 19-20 and 10 rows respectively. The posterior petals reach nearly half way to the margin.

(*b*) The highest part of the test is behind the apical system, about two-thirds the distance from it to the anus, upon the raised keel of the posterior inter-radials.

(*c*) The test is large, averaging about 6 centimetres in length. The following are the dimensions of one specimen—Length

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[1] *Rec. Geol. Surv. Ind.*, XXXIV, p. 91.

[2] *Ann. & Mag. Nat. Hist.*, 1888, 6th ser., Vol. II, p. 344.

[3] *Z. d. d. g. G.*, 1903, pp. 58—223.

[4] *Mem. de la Soc. Geol. de France, Pal. Mem.*, no. 32, 1904.

[5] *Mem. Soc. Geol. de France*, Tome X. Fasc. 1.

[6] *Note.*—This *P. subarcuatus* must be distinguished from *P. subarcuatus* Böttger from *the* Eocene of Borneo, *Paleontographica Supp.* III, Lief. I, *1875.*

[7] *Pal. Ind.*, Ser. XIV, Vol. I, pt. 4, p. 38, Pl. V, 5—49.

64 mm., breadth 60 mm., height 36 mm. A second specimen gives length 61 mm., breadth 54 mm., height 33 mm.

The latero-subanal fasciole corresponds with that of *S. baluchistanensis.* I am unable to trace the peripetalous fasciole distinctly, but it appears also to correspond.

The ornamentation closely resembles Duncan and Sladen's description.

As the object of this paper is not to make new species, but merely to establish as far as possible the age of the beds examined, it is sufficient to remark that *S. baluchistanensis*—apparently the nearest relative of the Burmese form—is of Nari age.[1]

(5) *Lucina globulosa* Desh.—I have already noted that these specimens were obtained from Burmans who reported the localities to me. It is possible, but, I think, improbable, that the localities were wrongly described, but if correctly, then they appear to be of Nari age. The species were figured by Dalton,[2] and Mr. R. Bullen Newton in the discussion on the former's paper, noted that this fossil "was evidence in favour of recognising those beds as belonging to the Helvetian-Tortonian portion of the Miocene system."

C. de Stephani[3] however quotes *L. dicomani* Menegh from the Tongrian of Colma di Rossiglione, and Sacco[4] states it to be an Eocene form closely allied to *L. globulosa,* noting at the same time the doubtful occurrence of *L. globulosa* in the Tongrian; there must therefore have been some intermediate types between these two species in the Aquitanian, so that there is little difficulty in supposing that a species of *Lucina* very closely allied to *L. globulosa,* and perhaps indistinguishable in the fossil state, should be found in Burma in beds of Aquitanian or later age. Dalton's species are from Padaukbin (Thayetmyo district), and are probably later than Aquitanian.

The *Vicarya* from bed "D" resembles the Gaj form *V. verneuili* d'Arch., but shows at least four keels between the rows of knobs; these keels do not appear to be granulated, but this may be due to the bad state of preservation. The height of one specimen is 115 mm. and the breadth of the last whorl 42 mm.

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[1] Vredenburg: Tertiary System in Sind, *Rec. Geol. Surv. Ind.,* XXXIV, p. 18 .

[2] *Op. cit.* Pl. LV, fig. 1.

[3] *Atti della Soc. Tosc. Sci. Nat.,* Vol. V, 1887, p. 270.

[4] *I. Moll, Terz. del Pied. &c.,* XXIX, p. 67.

Carda sp. cf. mutabilis is mentioned by Noetling from the Pegu beds [1]; Fedden calls the species a Khirthar form.[2]

In bed "E" *Corbula subexarata* is a Khirthar form (Fedden); the specimen of *Donax* is of rather common occurrence, and has been somewhat doubtfully referred to that genus (see figures on Pl. 18, figs. 6, 7, 9). The specimen recalls K. Martin's figure of *Corbula ovum*, (*Die Tert. auf Java*, Pl. XV, f. 8), but the valves are equal. The inner margin is crenulated. There is a ridge extending from the umbo to the anterior ventral margin; more ordinarily in *Donax* the ridge is posterior, but the modern species *D. scortum* (Reeve: *Conch. Ion.* VIII) shows two ridges. The ornamentation consists of concentric lines of growth, but when the outer layer of shell peels off the inner layers show very fine and regular radial striations crossed by concentric lines of growth.

Of the specimens from the "F" bed, *Trochus cognatus* is a Gaj form, and *Venus granosa* Gaj and Nari, (Fedden), but Dalton has found the latter in the Eocene.[3] Fedden does not give the horizons of *Surcula voyseyi* or of *Cardita keyserlingi*, but the former is known from the Ranikot,[4] and *C. scabrosa* a form allied to *C. keyserlingi* is found in the Pegu series.[5]

The occurrence of *Vicarya sp. cf. verneuili*, *Venus granosa* and of *Trochus sp. cf. cognatus* must be considered as fairly strong evidence in favour of these beds being regarded as of Nari age. The discovery of *Clypeaster* noted above is also additional evidence.

Khirthar Fossils.

From the bed at Kyet-u-bok, the following fossils are worth notice :—*Orthophragmina omphalus*, *Gypsina sp.*, *Nummulites beaumonti*, *Cardium ambiguum*, *Ficula sp.*, and *Campanile sp. cf. giganteum.*

(1) *Orthophragmina omphalus* Fritsch. (Pl. 18, fig. 4).—This species is described from Borneo by Fritsch,[6] and by Douvillé[7] from the collections of Dr. Buxtorf in Borneo.

The test presents a central depression, surrounded by an annular swelling; this again is surrounded by an annular depression at a distance of about one-third radius or less from centre. Outside of this the test swells out lightly near the marginal region. The test is always more or less saddle-shaped, and is usually about 20 mm. in size. Thus far it agrees with Douvillé's description. The external ornamentation does not appear to be quite the same. Douvillé's specimens showed granules of 0·09 mm. at distances of 0·04—0·06 mm. I find such granules upon my specimens, but I also find very many granules are of a much smaller size (0·03 or 0·04 mm. and upwards) and the distance of any two granules is often greater than 0·06 and even 0·09 mm. Douvillé says however that the external shape of this species is "tout à fait caracteristique," and I regard the slight difference in ornamentation as hardly more than varietal.

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[1] *Pal. Ind.*, New Ser., I, 3, p. 170.

[2] Fedden : On the Distribution of the Fossils described by Messrs. d'Archiac & Haime in Sind.—*Mem. G.S.I.* XVII, p. 197.

[3] *Op. cit.*, p. 612.

[4] Coss. & Piss.: *op. cit.*, p. 7.

[5] *Pal. Ind.*, New Ser., I, 3, p. 162.

[6] *Paleontographica Supp.* III, Lief. 1, 1875, p. 142, Pl. XVIII, f. 13; Pl. XIX, f. 5.

[7] *Bull. de la Soc. Geol. de France*, 4th ser., V, p. 440.

I have not been able to develop the central chambers satisfactorily.

This species characterises the Lutetian of Borneo.

(2) *Gypsina sp.* (Pl. 19, fig. 1).—The specimens were taken from a hard white limestone, from which it is a matter of difficulty to isolate the tests. These vary from 2 to 5 mm. in diameter, and are spheroidal in shape. The surface appears to be covered with granules and pits, but on cleaning the specimens carefully, it becomes evident that the granulation is not the true structure, which is entirely a pitted one.

Under the microscope, the cells of the central region are seen to be arranged in an obscure spiral, which at about half radius changes to a radiated structure, and the section recalls fig. 3, Pl. XV, of Carpenter's *Introduction to the Study of the Foraminifera*, where the figure shows *Tinoporus* (*Gypsina*) *vesicularis*, a species still living, and found extensively in the Miocene and Pliocene. Carter[1] has divided the genus *Tinoporus* into the sub-genera *Tinoporus* (*s. str.*) and *Gypsina*, the former name being restricted to *Calcarina*-like forms and the latter to the simpler varieties; the Burmese form should then be referred to the sub-genus *Gypsina*. In shape, it resembles *G. globulus* Reuss, figured on Pl. Cl. f. 8 of Vol. IX, *Report of the Sci. Results of the Challenger Exp.*

Carter[2] thus described *T. vesicularis* "The specimens are hemispherical and spheroidal respectively, depending upon their growing from a free or a fixed point: if from the former, they are sessile and hemispherical; if from the latter, free and spheroidal with a radiated structure in each instance, composed of conical columns of chambers, which chambers being alternate in adjoining columns, the circumferential chamber of one of the columns is only half developed, whereby the surface of the *Tinoporus* presents a pitted appearance..............”

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[1] *Report of the Sci. Results of the Chall. Exp.*, IX, p. 714.

[2] *Ann. & Mag. of Nat. Hist.*, ser. 4, XXI, p. 215.

It has been said that *Gypsina* is found in the Miocene and Pliocene[1]; it is also found in the Borneo Aquitanian,[2] and from the island of Nias[3] in conjunction with *Cycloclypeus* and *Nummites* (? =*Amphistegina*[4]) *Niasi I.*

Gypsina globulus is found together with *Orthophragmina* in the Eocene of Christmas Island, and Chapman[5] gives the range as Cretaceous to Recent.

(3) *Nummulites beaumonti* d'Arch. Dalton mentions this species as *N. beaumonti* ? I have compared my specimens with De La Harpe's description,[6] and find them to agree. Vredenburg places this species in the upper division of the middle Khirthar.[7]

(4) *Cardium ambiguum* Sowerby (Pl. 18, figs. 5, 8).—This is also mentioned by Dalton from this locality. In shape the shell exactly resembles Sowerby's figure,[8] but there are about 47 ribs, while Sowerby's figure shows 40. The specimens in the Museum are so worn that I cannot ascertain the number of ribs. The measurements of my specimen are : length 45 mm., breadth 39 mm., thickness 31 mm.

(5) *Ficula sp.*—Dalton states that *F. theobaldi* Noetl. is found in this locality. The specimens which I obtained, while showing a very close resemblance to that species in ornamentation, differ in having a taller spire ; this is only what was to be expected, since Sacco[9] in his description of *F. condita*—a species which resembles *F. theobaldi*—says “ The fact that generally the spire is more elevated and the transverse ribs less developed in the Tongrian forms of *F. condita*, but not in the Helvetian forms, can perhaps be interpreted by supposing that the Eocene forms from which *F. condita* was

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[1] *Chall. Exp.*, IX, p. 717.

[2] *Bull. de la Soc. Geol. de Fr.*, 4th ser., V, p. 445.

[3] Verbeeck and Fennema : Descr. Geol. de Java & Madura, p. 1158.

[4] *Rec. Geol. Surv. Ind.*, XXXIV, p. 93.

[5] Chapman ; The Foraminifera, p. 225 : and Andrews ; A monograph on Christmas Island, p. 229.

[6] *Paleontographica*, XXX, i, p. 180.

[7] *Rec. Geol. Surv. Ind.*, XXXIV, p. 94.

[8] *Trans. Geol. Soc.*, 2nd ser., Vol. V, Pl. XXIV, f. 1.

[9] *Moll. Terz. del Pied. &c.*, VIII, p. 25.

derived, had just an elevated spire and were destitute, or almost so, of the ribs mentioned above, characters after all, which many Eocene forms present, as *F. nexilis*, *F. Pannus*."

(6) *Campanile sp. cf. giganteum* Lmk.—The specimen is merely a fragmentary cast, showing about two whorls, the largest whorl being about 12 cm. in diameter. *C. giganteum* is found in the upper part of the Lower Calcaire Grossier of Paris.[1] Newton describes a *Campanile sp. cf. giganteum* from Somaliland,[2] and remarks "All these large forms of *Campanile* appear to be characteristic of middle Eocene times." *Campanile* also occurs in the Nummulitics of Oman.[3]

Of the remaining specimens from Kyet-u-bok, *Meretrix sp. cf. parisiensis* resembles the form from the Paris eocene; *Ampullina sp. cf. sindiensis* resembles the figure in Cossmann's and Pissarro's memoir on the Ranikot mollusca[4]; while *Conus brevis* Sow. has four whorls and thus resembles the form described by Cossmann and Pissarro[5] from the Ranikot, rather than Noetling's[6] *C. literatus*, which has "about nine whorls," but with reference to which Noetling remarks "there is no doubt that *C. brevis* is identical with the species here described."

Of the fossils from the "G" bed, *Velates schmideliana* is placed in the Khirthar and Ranikot by Fedden. Noetling[7] has proved that this *Velates* is identical with the Paris species, but Cossmann and Pissarro[8] say "the specimens from Sind (and) from Burma figured by Noetling belong to a later horizon than the Ranikot. We are unable to say whether they correspond with *V. noetlingi* or with *V. schmideli*."

Cypræa elegans has been found by Dalton[9] in beds which he states to be of Miocene age, but he notes that it characterises the Lutetian of Paris and Egypt. *Volutospina sykesi* seems to be the same as, or extremely similar to Dalton's species *Voluta d'Archiaci*.[10] *C. literatus* shows 8-9 whorls. *Venus subovalis* is of Khirthar age, and *Voluta jugosa* Ranikot to Nari (Fedden).

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[1] Geikie: Text book of Geology, p. 1237.
[2] *Q. J. G. S.*, LXI, 1905, p. 161.
[3] *Mem. Geol. Surv. Ind.*, XXXIV, pt. 4, p. 20.
[4] *Pal. Ind.*, New Ser., III, mem. I, p. 77, Pl. VII, f. 1, 2.
[5] *Ibid.*, p. 18.
[6] *Pal. Ind.*, New Ser. I 3, pp. 359-360.
[7] *Rec. Geol. Surv. Ind.*, XXVII, p. 103.
[8] *Op. cit.*, *p.* 77.
[9] *Op. cit.*, p. 615.
[10] *Ibid.*, 640.

The most common species of this bed however is ***Operculina sp.*** Dalton mentions *O. canalifera* d'Arch.[1] The *Operculina* is found in a thin bed at the top of the section at G. 2, containing Eocene fossils, *e.g.*, *Velates schmideliana*, but there is no proof that the *Operculina* bed is itself Eocene, since no Eocene forms have been found above it. Chapman[2] describes *O. canalifera* as a variety of *O. complanata.* D'Archiac's *O. canalifera* is 10-12 mm. in diameter,[3] while my specimens from Burma average 3 mm.

Of the remaining fossils, the most interesting occurrence is that of *Nummulites vredenburgi.* The outside whorls from the 7th to the 10th are more or less deformed. I have only found the microspheric form. It will be remembered that this species was originally described as *N. douvillei* Vred.[4], and was subsequently renamed *N. vredenburgi* Prever.[5]

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[1] *Ibid*, p. 612.

[2] *Geol. Mag.*, 1900, p. 314.

[3] Descr. des An. Foss. de l'Inde, p. 182.

[4] *Rec. Geol. Surv. Ind.*, XXXIV, p. 79.

[5] *Rec. Geol. Surv. Ind.*, XXXVI, p. 259.

EXPLANATION OF PLATES.

PLATE 17.

PLATE 17.—Fig. 1.—*Heterostegina sp.*, nat. size.
Fig. 2.— ,, another specimen, nat. size.
Fig. 3.— ,, another specimen, nat. size.
Fig. 4.—*Lepidocyclina mantelli*, var. *theobaldi* Carter, nat. size.
Figs. 5, 6.—*Pecten* (*s. str.*) sp. left valves, internal view, nat. size.
Fig. 7.—The same, right valve, nat. size.

PLATE 18.

PLATE 18.—Fig. 1.—*Schizaster* sp. actinal view, nat. size.
Fig. 2.—The same, abactinal view.
Fig. 3.—The same, side view.
Fig. 4.—*Orthophragmina omphalus* Fritsch, mag. 2 diameters.
Fig. 5.—*Cardium ambiguum* Sow., nat. size.
Figs. 6, 7 and 9.—*Donax* sp.
Fig. 8.—*Cardium ambiguum* Sow., lateral view.

PLATE 19.

PLATE 19.—Microphotograph of section of *Gypsina* sp. magnified 16 times.

PLATE 20.

PLATE 20.—*Heterostegina* sp. (possibly a different species from that figured on Pl. 1, figs. 1, 2, 3) magnified 16 diameters.

PLATE 21.

PLATE 21.—Geological map of portion of the Minbu district, Upper Burma, near Ngape. Scale 1″ = 1 mile.

THE GEOLOGY OF THE HENZADA DISTRICT, BURMA. BY MURRAY STUART, B.SC., F.G.S., F.C.S., *Professor of Geology, Presidency College, Madras.* (With Plates 22 to 24.)

GEOLOGICAL SUMMARY.

Main divisions of the district.

THE district is divided into an eastern and a western region by two approximately straight lines of fault which meet at an angle of about 160° near the village of Kywezin, with the apex pointing towards the east. The western region is entirely occupied by a monotonous series of very hard indurated sandstones and shales, often veined and infiltrated with silica, known in the publications of the Geological Survey of India as the Negrais beds. This western region is entirely occupied by the high land and mountainous country which composes the eastern flank of the Arakan Yoma.

The eastern region of the district exhibits a far more varied geological sequence and is composed of sandstones, shales, limestones, and grits, of Tertiary age. This is much covered and concealed by extensive deposits of plateau gravel (Older or Red Alluvium). In both regions the strata have been folded and contorted. In the western or Negrais region there is evidence of intense dynamic disturbance, the rocks being crushed, contorted, and locally faulted, in a manner which precludes the possibility of mapping them in anything like detail on so small a scale as 1 inch = 1 mile, the largest scale on which maps of the region are available at the present time. In the eastern region the folding is less intense, the main structure being a wide syncline in the Tertiary rocks. This syncline is repeated and shifted by faults, which are numerous and important in this region.

These differences in composition and structure have exerted a considerable influence in determining the physical features of the two regions, the western being characterised by high, steep, hills and mountains, while the eastern region is comparatively low lying country; the change from this to the high land comprising the western region is the most distinctive feature of the district. The eastern region comprises the whole of the district from a political point of view, the western or Negrais region being entirely uninhabited and covered with dense and often impenetrable jungle. With the exception of one or two fire lines cut by the Forest Department in the north of the district this western region is entirely devoid of roads other than game tracks.

The eastern region.

The eastern region is occupied by rocks of Eocene, Oligocene, Miocene, and probably also of Pliocene age. As I have already mentioned, these rocks consist of sandstones, shales containing a band of limestone in their uppermost beds, and grits. Geologically they include representatives of the Eocene, the Pegu System, the Irrawaddy System, as well as superficial formations of Pleistocene and Recent age. The remarkable series of rocks which I distinguished in the Prome district under the name of "Marine Irrawaddy" are also beautifully exposed in the Henzada country. The name "Marine Irrawaddy" was adopted in accordance with the position of the series and its relationship to the rocks of the Prome district, as the classification established by both Theobald and Noetling included part of these series of marine beds amongst the strata which they respectively designated as "Fossil-wood-group" and "Irrawaddy System" and part of it in the "Pegu System." In Upper Burma however Dr. Noetling included within his Pegu System certain beds which are regarded by myself and by my colleague Mr. Cotter as the equivalents of these "Marine Irrawaddys." The unconformity, or rather the "stratigraphical gap" (the result no doubt of a marine regression), at the base of this subdivision, though often very slight in point of geological duration, is very widespread. According to my colleague Mr. Vredenburg it is just as pronounced in many parts of Sind and Baluchistan as it is in Burma, and frequently isolates the uppermost Gáj (Zone of *Ostrea latimarginata*) from all the underlying beds many stages of which may be missing, so that marine beds of the uppermost Gáj may rest indifferently upon the Lower Gáj, the Nari, the Khirthar or the Laki. Just in the same way as Fedden and Theobald, in their survey of Lower Burma, incorporated this bed with the Fossil-wood Group (Irrawaddy or Siwalik), so did Fedden and Blanford in their survey of Lower Sind incorporate it with the Manchhar (Siwalik), with the result that to the north, north-east and east of Karachi, a considerable area has been mapped as "Manchhar" which really belongs to the older Gáj or Hingláj. According to Mr. Vredenburg the stratigraphical break is not indicated by any discordance of stratification. The dividing line between the uppermost Gáj and Manchhar is even less marked than that between the Upper Gáj and the underlying formations, although the geological interval, in this case, is considerable, since the basal beds of the Manchhar contain a mammalian fauna which cannot be older than "Sarmatian," while the upper Gáj belongs to the very base of the Burdigalian. Similarly, in Lower Burma where the rocks are greatly concealed by soil and alluvium, one may be at a loss to know where to draw the dividing line between the Pegu and Irrawaddy Systems. There is perhaps some inconspicuous dividing line above the marine beds here alluded to that may have hitherto escaped my attention; or else the base of the Irrawaddy System may correspond with certain disturbed gravels which I shall have occasion to mention in the sequel of this paper.

In Upper Burma a conspicuous ferruginous bed constitutes a readily recognisable line of demarcation between the Pegu and Irrawaddy Systems. I failed to notice this band above the fossiliferous beds of the "Marine Irrawaddy," but it is quite possible that its equivalent should be sought at the base of the gravel beds just alluded to. In order to solve this interesting question we must await the geological examination of the unsurveyed area intervening between the portions mapped in Upper and in Lower Burma.

In my description of the Prome district I correlated my "Marine Irrawaddy" with the Upper Hinglaj. Mr. Vredenburg, who has examined the fossils which I obtained from this stage in Henzada, is of opinion that they coincide not with the Upper Hinglaj but with the lowermost Hinglaj; he is therefore disposed to regard the stratigraphical gap in Burma as analogous with that occurring in Sind and Balúchistán. It is therefore evident that the so-called "Marine Irrawaddy" is much more closely connected with the Pegu system than with the Irrawaddy system, and, after discussing this question of nomenclature with my colleagues Mr. Cotter and Mr. Vredenburg, I agree that the designation adopted for these beds might be misleading. At the same time their situation above a remarkable stratigraphical gap entitles them to rank as a separate subdivision, and as it would be unsafe in the present state of our knowledge to transfer the names of the geological formations of western India to Burma, and *vice versâ*, I propose to name them the "Akauktaung" series because the celebrated carved rocks of Akauktaung situated on the bank of the Irrawaddy some 24 miles above Myanaung, and the ranges of hills associated with them, which are also called Akauktaung, include rocks of this series. I have not adopted Theobald's designation of "Mogaung sands" owing to the uncertainty as to whether the upper part of this division may not belong in reality to the Irrawaddy beds.

I may here mention that according to Mr. Vredenburg's latest researches the so-called Nari vertebrate fauna of the Bugti hills in Balúchistán occurs in a series of strata the basal members of which are marine and correspond with the Uppermost Gáj, so that the age of these beds is Uppermost Gáj to Lower Hinglaj, exactly as had originally been predicted by Mr. Vredenburg.[1] The marine transgression which Mr. Vredenburg has observed all through Sind at the base of the Burdigalian and which I have now traced in Burma, therefore reached also the Bugti region, and it is evident that the bone-bearing beds of the Bugti Hills also correspond with the Akauktaung series. The presence of the Bugti fauna in the Kuldana beds at the base of the Murree series also brings the latter into line with the Akauktaung division.

In the north of the region is a syncline of highly fossiliferous yellow grits which are the basal members of the Akauktaung series. This syncline terminates naturally in the north at Akauktaung, the celebrated carved rocks at the extreme north of the district; in the south it is cut off abruptly by a fault running approximately east and west through Petyi. East of this syncline is a faulted anticline of Sitsayan shales, which are lying underneath the above mentioned grits and are covered unconformably by them. The position of the centre of this anticline, if it can be called an anticline, appears to be occupied by a fault running approximately north and south, the position of which is indicated by groups of mud volcanoes. East of this line of fault the Akauktaung grits again appear dipping in an easterly direction, and form a slight ridge running approximately north and south through Pauktaing. This outcrop can be traced north across the Irrawaddy river into the Prome district until it finally disappears beneath alluvium a few miles below Shwedaung.

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[1] *Rec. Geol. Surv. India*, Vol. XXXIV, p. 92 (1906).

The unconformity between the Akauktaung grits and the underlying Sitsayan shales can be clearly seen, and is exemplified by the fact that west of the fault there is a band of limestone in the shales lying close underneath the grits, whereas east of the fault this limestone band does not appear but is covered up and concealed by the grits. South of this area the region is much covered and hidden by Plateau gravel deposits, but the synclinal structure is again seen between Kyaukpazat and Tondaung, the massive limestone hill east of the village of Yenandaung. South of this the structure is obscure. The region is undoubtedly much faulted underneath the Plateau gravel, but in most cases it is impossible to indicate even the possible position of the faults. All that can be done is to map the beds as they show through the gravel. These have a general easterly dip and nowhere give any indication of anticlinal structure. The isolated exposures of limestone help to give some slight clue as to the underground structure, because the microscopical examination of the foraminifera contained in the different outcrops confirms the view that they are all parts of the same limestone. Even with their aid, however, it is impossible to produce an infra-gravel map of the district.

The extreme west of the region is occupied by sandstones containing no fossils other than carbonaceous markings and occasionally coal. These sandstones seem to form a series which is covered unconformably by the shale series just discussed. The faulting which has taken place in the region and the extensive covering of Plateau gravel render it practically impossible to trace the overlap along the junction of the two series of beds; but it is clearly seen in the different exposures that there is a variation in the thickness of sandstone beds which intervene between these containing carbonaceous markings and the base of the overlying shale group.

The Akauktaung series.

The marine grits and sands which form the uppermost infra-gravel series of the region belong to the Akauktaung series, corresponding to the beds which I formerly classified as 'Marine Irrawaddy series.'[1] They rest unconformably on the underlying shales, the unconformity being revealed in the field by the lower angle of dip of the grits and sands, and also by the fact that the basal beds overlap bed after bed of the shale series. In character the series resembles exactly the 'Marine Irrawaddy series' of Prome.

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[1] *Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 260.

It consists of coarse grits, occasionally conglomeratic, which vary in colour from yellow to red, and soft yellow sandstones which resemble the yellow sandstones of the over-lying fresh-water Irrawaddy series in a remarkable degree, both in appearance and in the way they weather, differing only in that they contain marine fossils.

In addition to these, blue shales are occasionally developed, and occasional bands of hard calcareous sandstone are seen. These latter quickly weather to loose yellow sand, however, which resembles the weathered sand from the yellow sandstones mentioned above. In the field the series is characterised by ridges of coarse grits, ferruginous in places, which are filled with fossils, and gentle undulating country, characterised by loose yellow sand sometimes containing kankar.

Fossils are plentiful throughout, the grits being characterised by the abundance of the genus *Ostrea* amongst the forms.[1] Otherwise the fossils do not differ remarkably from the fauna described by Nœtling as coming from the Pegu system.[2]

The *Ostrea*, which occur in this series, are very difficult to extract from the rock in an unbroken condition, but I have succeeded in obtaining some from the basal grits near Yethyauksan, some five miles north of Pauktaing. According to Mr. Vredenburg they include the following forms: *O. gingensis* (regarded by Mr. Vredenburg as identical with *O. crassissima*, typical forms of which also occur), *O. digitalina* Eichw. var. *Rholfsi* Fuchs (=*O. promensis* Noetl.), *O. Virleti* Desh. (=*O. peguensis* Noetl.), and two specimens of a very large ponderous form, probably *O. crassicostata.* The simultaneous occurrence of the three last forms is of great stratigraphical interest in so far as *O. Virleti*, *O. Rholfsi* Fuchs, and *O. petrosa* Fuchs (a form closely related to the one here mentioned as *O. crassicostata*) have been found associated by Mr. Vredenburg at a low horizon of the Lower Hinglaj; while Tietze obtained the same association of all three forms in the Siah-Koh near Teheran in beds which Fuchs refers to the horizon of Loibersdorf, that is to the base of the Burdigalian. According to Mr. Vredenburg, *O. gingensis* (with "*O. crassissima*") occurs abundantly in Sind in the zone of *O. latimarginata.* We may therefore correlate the base of the Akauktaung series with the base of the Hingláj on the one hand, and on the other hand, with the base of the Burdigalian of Europe.

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[1] *L.c.*, p. 266.

[2] *Pal. Ind.*, New Ser., Vol. 1.

In addition to the above mentioned *Ostreæ*, I have found the following forms :—

Arca burnesi d'Arch. & Haime.
Cytherea erycina Fav.
Dione dubiosa Noetl.
Turritella simplex Jenkins.
Turritella acuticarinata Dunker.
Turritella sp.
Conus literatus Linne.
Conus avaensis Noetl.

which are common forms in the Pegu system.

These beds all belong to the Akauktaung series in Henzada, but east of the river in the Prome district one observes an apparently gradual passage of this marine series into the overlying fresh water beds referred by Theobald and by Noetling to the Fossil-wood or Irrawaddy series. though, for the present, this attribution must remain doubtful. The junction was observed by Theobald on the east bank of the Irrawaddy opposite Kyangin, north of Myanaung. On his map he calls the village Kyankeng and in his description refers to it as Keng yua; the old way of spelling it (Kyan-keng), and his explanation that it is close to Myanaung, however, makes it quite clear which village he means when he refers to Keng yua, "yua" being simply the Burmese word for village. I have also made certain by full enquiries that no other village with a name resembling Keng-yua exists or has existed within the neighbourhood of Myanaung and therefore it is quite certain that the village referred to by him is the village he spells on his map Kyan-keng and which is now spelt Kyangin on the government maps. His section, which I give below, leads one to believe that the 'Mogoung sands' division of his 'Fossil-wood group' corresponds to the uppermost beds of the series that I originally called the 'marine Irrawaddy series' but which I now call the Akauktaung series. It is especially interesting in that he mentions the existence of rolled oysters among the marine forms. He says :—
"To the present division of the fossil-wood group"—(Mogaung sands) "may probably be referred the beds rather imperfectly seen in the East bank of the 'Irrawadi,' close to Keng-yua, above

Myanoung. The beds here exposed dip nearly due east, about 30°, and are cut so obliquely by the river that their thickness cannot be very closely measured, and unfortunately the most interesting bed containing bones is the lowest in the section and to a great extent covered by the river.

(*Descending Order.*)

	Ft.	In.
1. Yellow earthy sandstone with irregular concretionary or lenticular courses of fine sandstone, which weathers out from the softer rock enclosing it somewhat after the fashion of kankar nodules, which it superficially resembles		
2. Harder sandstones of similar character, resting on yellow sand containing marine shells	80	0
3. Brownish clunchy clay passing down into blue clay	30	0
4. Sandstone like No. 1 passing down into	30	0
5. Rather false bedded conglomerate	60	0
6. Yellow sandstone	30	0
7. Wet sandy clay (many springs)	6	0
8. Yellow sandstone with conglomerate courses containing shark's teeth, rolled oysters, chelonian plates, and bones, some apparently mammalian "		

As far as can be calculated, then, the thickness of the Akauktaung series in this district, measuring from the base of the series where it runs through Pauktaing to the base of the fresh-water Irrawaddy series across the river in the Prome district, is about 4,000 feet. It seems to pass up into the freshwater Irrawaddy series without any observable unconformity.

The outcrop of these Akauktaung beds in the district is almost entirely covered with reserved forest, the vigorous growth of the vegetation and trees being a feature which at once distinguishes them from the more stunted growth on the shales and clays of the district.

The Sitsayan shales.

The shale series which is seen underlying the Akauktaung grits corresponds to the Sitsavan shales of the Prome district. The shales are blue, somewhat clunchy clays, with very little appearance of bedding, except towards their upper portion, where a band of limestone is developed. When dried the clay is of a very pale colour and falls to pieces spontaneously. Occasional irregular layers of fibrous marl and of hard yellow marl traversed by shrinkage seams or septarian cracks, filled by carbonate of lime, occur in the clays;

very occasionally cone in cone structure is developed. In addition to the above irregular layers of hard yellow marl traversed by carbonate of lime, which are such a feature of the Sitsayan shales in Prome,[1] there are also irregular layers of pale blue or grey marl, also traversed by septarian cracks filled by carbonate of lime, but these cracks are not so strongly developed as in the yellow marl. The chief difference between the Henzada facies and the Prome facies is, however, the occurrence of the band of limestone towards the top of the series in Henzada. This limestone is massive in places, as at Tondaung near Yenandaung, where the entire hill of Tondaung is composed of massive limestone; in places it consists of a series of thin flaggy limestones with shaly partings, as in the ridge west of Pauktaing; but as a general rule it consists of massive limestone. The limestone itself is a white limestone showing a pink colour in places. According to my colleague Mr. Cotter, who has kindly examined microscope sections of this rock, it is crowded with small lepidocyclines in which the two central cells appear to be disposed tangentially as in *L. Raulini* and *L. dilatata*, and also with small nummulites and occasional fragments of *Cycloclypeus*. Mr. Cotter is of opinion that this bed corresponds in age with some portion of the Nari of Sind. In my paper on the Prome region I had also suggested that the Sitsayan shales probably correspond with the Nari.[2] In the present instance the direct superposition of the Akauktaung series implies a considerable geological hiatus.

These Sitsayan shales and the included limestones are all mapped and described by Theobald as belonging to his " Nummulitic series " in this district. To this he was no doubt led by the appearance of the lepidocycline limestone, which is indistinguishable in hand specimens from the nummulitic limestone of Thayetmyo and Prome, and it is only by examination in rock sections under the microscope that the difference can be seen. The result of this was that he classed this limestone in Henzada as the topmost member of his Nummulitic series,[3] which, therefore, must include Oligocene as well as Eocene beds. This " Nummulitic series " of Theobald can be traced at intervals from near Phoungyi to the Pyengma stream in the Bassein district, a distance in a direct line of two hundred and twenty-four miles.

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[1] See the description of the Sitsayan shales given by Theobald—*Mem. Geol. Sur. Ind.*, Vol. X, Art. 3, p. 82.

[2] *Rec. Geol. Surv. Ind.*, Vol. XXXVIII, p. 279.

[3] Theobald, *l. c.*, p. 100.

The limestone exposed near Kyaukme in the Thayetmyo district, although on this line and almost identical in hand specimens, does not contain any lepidocyclines, but on the other hand contains eocene nummulites. It is therefore eocene and does not coincide with the Henzada limestone with lepidocyclines.

The sandstone series.

Below the Sitsayan shales is the sandstone series, which has hitherto yielded no fossils other than carbonaceous markings. The exact position of this series is, therefore, difficult to fix with certainty. It consists of massive sandstones ranging in colour from green to yellow, grey, and blue. Shales are almost entirely absent throughout the series. Occasional conglomerates occur and towards the base the rocks are much indurated. Carbonaceous markings are common, but there is no trace of any other fossil. In Prome the beds which underlie the Sitsayan shales are, as I pointed out in my description of that area, eocene, and, moreover, as one traces the base of the Sitsayan shales in a southerly direction, it is seen to overlap on to lower and lower beds of the Nummulitic series. It seems probable, therefore, that the beds underlying the Sitsayan shales in Henzada occupy a lower place in the Nummulitic series than those exposed in the Prome district.

On pages 102 and 134 of his memoir Theobald gives a section taken from the Hlowa stream, of which the upper 4,117 feet belong to the Nummulitic series. The rocks above Yuathit village are chiefly sandstones, but the distinguishing feature of the section below the village seems to be sandstones with carbonaceous markings. That this section represents beds low in the series is shown by the fact that some miles to the east another section is seen near Thanbula which is given in detail by Theobald on page 98, the latter section undoubtedly being much higher in the Nummulitic series than that exposed in the neighbourhood of Yuathit on the Hlowa stream. It seems likely therefore that the sandstone series exposed in Henzada, which is characterised by sandstones with carbonaceous markings and also contains coal seams, corresponds to the section in the neighbourhood of Yuathit village; in this case they probably correspond to the Laki series in India, the coal-bearing series of Baluchistan and the Punjab, since the geology of the Tertiary rocks of those regions seems to correspond very closely to the geology of the Burmese Tertiaries. The point must be emphasized however that this is only assumption, although it carries a high degree of probability. Indeed, in the Minbu district Mr. Sethu Rama Rau has observed carbonaceous shales situated above beds containing Nummulites identified by Mr. Cotter as *N. Vredenburgi* and therefore of Khirthar age. Since the series is covered unconformably by the Sitsayan shales, and is cut off at the base by a fault, it is impossible definitely to fix its age until fossil evidence has been obtained; but as no pre-nummulitic rocks are known in Pegu between the confines of the Yomas it is practically certain that these rocks belong to some division of the Nummulitic series, and, that being so, the Laki series is the one with which they could most probably be correlated. The Plateau gravel I will discuss in a separate paragraph under the heading of Recent formations.

The Negrais Region.

This region is characterised by a monotonous series of indurated sandstones and shales, with frequent cherty beds, and contains the Negrais rocks described by Theobald. In addition to these, however, I use the term to include all the indurated, sub-metamorphosed rocks which form the high land of the Yoma, without including in the name any inference as to the geological age of the rocks. Theobald classed under the term Negrais all rocks of pre-nummulitic age which are younger than his Axial series, considered by him, to be of Triassic age. In the Henzada district there is no evidence as to the age of the rocks which compose the western region. They are bounded at the top by faults and contain practically no fossils. The only fossils which have ever been obtained from them are a few badly preserved specimens of what appear to be a species of *Vicarya*, preserved in iron pyrites, which I obtained from a shaly bed some nine miles west of Myinwadaung. In the northern portion of the district the fault which forms their upper boundary does not coincide with the strike of the beds but crosses them obliquely, the Negrais beds striking approximately south 10° west, while the line of the fault is approximately south 10° east. This means that the uppermost Negrais beds exposed towards the middle of the district are younger than the uppermost Negrais beds exposed in the north of the district, since they have a general easterly dip of about 45°. The fault bounding this region does not seem to be disturbed by the numerous cross faults which have cut up the eastern region, except in the neighbourhood of Kywezin where the line of the fault has been shifted almost half a mile, and its direction swung through about 20°. The term Western region seems to me to be the best to apply to this series of rocks until some definite work is done upon them and some evidence of their age and position in the geological scale is obtained. If the Yoma represents an uplift, as is, I believe, generally accepted, then these rocks must be very largely of pre-nummulitic age in Henzada, and this is a point which will have special bearing on the economic value of the region, which will be discussed by me fully in the second part of this paper. As the upper boundary of the region is a fault which cuts the bedding obliquely, there is no reason why the Negrais rocks of Prome and Thayetmyo should correspond in age to those in Henzada, although owing to the induration and sub-metamorphism which they have undergone they may appear to be identical in the three districts. The only course open to us at present would, therefore, seem to be to regard the rocks of the Western region as a petrographical rather than as a stratigraphical unit.

Recent formations.

In the eastern part of the area there are two sets of gravel beds—an upper division consisting of soft loose gravels and sands, and a lower division consisting of gravels generally and more consolidated, often lateritic. These two divisions seem to be quite distinct, and whereas the upper division is always approximately horizontal the lower division is often dipping and seems to be involved in the folding and faulting movements which have affected the older rocks. Although most of the Plateau gravel in the Henzada district belongs to the upper division and consists of loose gravels and sands, yet the lower division consisting in this district of lateritic gravel is well seen in places and is involved in the faulting and folding movements which have affected the underlying rocks. I had not the time at my disposal to separate these two divisions throughout the district, but as a general rule the lower lateritic division of the gravels is seen west of the north and south fault running near Yenandaung and Hngetkyi. East of this fault the gravels consist of the loose unconsolidated sandy gravels belonging to Theobald's upper division. The lower lateritic division thickens towards the east throughout the district, as can be seen by a study of the maps published with this report. In the west of the region the gravel is only a thin deposit and the streams have cut down through it and exposed the underlying rocks; towards the east, however, the deposit increases in thickness until the underlying rocks are not exposed even in the drainage channels of the district.

These lower gravels are seen to lie on the top of the older rocks and cover indiscriminately Akauktaung grits, Sitsayan shales, and Nummulitic sandstones.

That they are involved in the faulting movements of the district, is well seen at Thitsitaung (hill), where this lateritic gravel, at least 300 feet thick, is lying unconformably on the Akauktaung series; the fault east of the hill repeats the structure and brings the Akauktaung grits against the gravels east of the fault.

It is evident, therefore, that these older gravels should be classified with the Irrawaddy system, though whether they be the basal members of the Irrawaddy or an upper member cannot be decided until the survey of Henzada and Prome has been connected with that of Upper Burma.

The character of the gravels in the two divisions is quite distinct; the older lateritic gravel is consolidated by a ferruginous cement and often lateritic in appearance, whereas the newer gravels are loose gravels and sands.

The Plateau gravels are much covered with forests of 'in' trees, and much of their surface is covered with forest reserves. The peculiar selection the 'in' tree seems to exhibit for the gravels is the great feature of the Plateau gravel country and the distinction between the gravel and the shales is clearly marked by the vegetation, the former being generally covered with 'in', while the latter have abundant bamboo and teak.

Intrusive Rocks.

In the south of the district, and in the north of the Bassein district, some twenty-one masses of intrusive serpentine occur situated along, or in close proximity to, the fault separating the Western from the Eastern region. These masses of serpentine are fully described by Theobald[1] and their position is marked on his map. They do not call for any special mention beyond what has already been given by him. They consist of typical serpentines in some parts of which a small portion of the original olivine remains in a state of only partial decomposition, but in the majority of which the conversion into serpentine is complete. Each mass is surrounded by a zone of alteration in which the sandstones and shales show a gradual transition into iron-stained schists containing much white quartz.

In the neighbourhood of Wadawkwin and Kyibin a carbonaceous shale or impure coal-seam is altered into an impure graphite and graphite-schist where it has been traversed by the intrusive masses.

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[1] *Mem. Geol. Surv. Ind.*, Vol. X, pt. 3, pp. 143, 148.

Conclusion

The most important result of my last season's field work is the recognition that the stratigraphical gap, discovered last year to exist below the Akauktaung series[1] in the Prome and Thayetmyo districts, is continued into the Henzada district; and here the whole of the Upper and Lower Prome series has been apparently overlapped by the Akauktaung series, which is resting directly on the Sitsayan shales. This means that the Kama clays, the upper and lower Prome sandstones, and the topmost beds of the Sitsayan shales, are missing in this district. Either they were removed by denudation during the period preceding the lower Burdigalian marine transgression or else what is just as likely, they were never deposited. The annexed table expresses the views which I share with Mr Cotter and Mr. Vredenburg regarding the correlation of the Tertiary beds in Burma with those of Sind and Baluchistan.

Table showing the correspondence of the Eocene, Oligocene, and Miocene Strata in Sind Baluchistan and in Burma.

EUROPE		SIND AND BALUCHISTAN	BURMA	
Sarmato-Pontian		Lower and part of middle Manchar and Siwaliks	Lower part of Irrawaddy Series	
		Second Phase of Himalayan Upheaval	Unconformity mapped as boundary between Irrawaddys and Pegus	
Vindobonian		Upper Hinglaj	(Not known in Burma.)	
Burdigalian	SERIES	Lower Hinglaj with *Ostrea digitalina*, *O. virleti*, *O. petrosa*, etc.	Beds with *O. digitalina*, *O. crassissima*, etc.—Akauktaung Series	PEGU SERIES
		Uppermost Gáj, base of Hinglaj beds	Frequent stratigraphical gap	
Aquitanian		Gáj Beds	Prome stage and Kama clay with Gáj fossils	
	MEKRAN	Nari: Upper (with *Lepidocyclina dilatata* and *L. elephantina*.)	Beds with *Lepidocyclina theobaldi*, *Heterostegina sp.*, etc. (Sitsayan Beds.)	
Oligocene		Nari: Lower (with *Nummulites intermedius* and lepidocyclines.)	*Clypeaster* beds	
Bartonian		First Phase of Himalayan Upheaval		
Lutetian		Khirthar stage . . .	Beds with *N. vredenburgi*, *N. beaumonti*, *Velates schmideli*, etc.	
		Laki stage	Beds with *N. atacicus* and *A. granulosa*	
Lower Eocene .		Ranikot stage	(Not known in Burma.)	

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[1] The Marine Irrawaddy series of previous publications.

ECONOMIC CHAPTER.

The Negrais Region.

Owing to its thick jungle and absence of paths I did not do any detailed prospecting in the western region. I have had several specimens of iron pyrites brought to me from it, but in no case did the deposit seem to be extensive enough to be of any economic interest.

The region seems to be practically, if not entirely, devoid of limestone, and the only economic value of the rocks which comprise the region is for road metal, under which heading I will discuss them below.

There is a large number of salt springs in the region which are all marked on Theobald's map, but no salt is being extracted. Owing to the fact that this region is separated from the eastern region by a fault, and that the western region represents an uplift, none of the beds which crop out in the eastern region are repeated west of the fault. The section, given by Theobald in the Hlowa stream and which I have already mentioned, shows that there is no indication of coal in the bed below those with the carbonaceous markings in what he terms the Nummulitic series, nor has he observed any coal in any beds below this. One can therefore predict almost with certainty that no coal occurs in the western region.

The Eastern Region.

In the eastern region the minerals which have been exciting most interest are coal and petroleum; the coal has been spasmodically investigated by different people for the last twenty-eight years, and although numerous oil concessions have been taken up, no effort had been made to prove any of them up to the time of my visit.

1.—Coal.

As I have already stated the coal occurs in the basal sandstone series of the eastern region. It is seen in isolated outcrops, and the seam has been much shifted and affected by the faulting which has taken place in this region. The chief outcrops of importance are at Posugyi, Kywezin, Hlemauk, and Kyibin, which I will consider separately.

Posugyi Outcrop.

The outcrop of the coal-seam occurs some four miles to the west of Posugyi on the left bank of the Padaw stream. The seam varies from twenty inches to six inches in thickness. The dip is steep, varying from 45° to 60°, in an approximately easterly direction. It occurs exceedingly close to the main fault which separates the eastern region from the Negrais region, and, as is to be expected, the strata surrounding the coal are much contorted. Owing to the thinness of the seam, the steepness of its dip, and the contortion of the surrounding rocks, I do not think that the occurrence is of any economic value.

The coal was analysed by Dr. R. Romanis, Chemical Examiner, British Burma, in 1882 with the following result[1]:—

Moisture	6·36
Volatile matter	18·21
Fixed carbon	69·65
Ash	6·82

The high value of the fixed carbon is probably the result of the fact that the strata have been much crushed and contorted.

Kywezin Outcrop.

This locality is by far the most promising in the district. The coal crops out in the Nipasi stream some six miles from Kywezin and is also met with in the Theye stream, just to the north of the Nipasi stream. It seems to occupy the same horizon in the sandstone series as the coal at Posugyi; it is dipping in a direction east 10° south and appears to be about ten feet in total thickness.[2] Various analyses of this coal have been made which I will consider first, before discussing the geology of the locality.

In 1875 a sample of this coal was sent to the Geological Survey of India, by the Government of Burma, for analysis. An analysis was made by Mr. Tween, with the following result:—

Moisture	2·0
Volatile matter	13·2
Fixed carbon	78·3
Ash	6·5
	100·0

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[1] *Rec. Geol. Surv. Ind.*, Vol. XV, pt. 3, p. 181.

[2] See Romanis, *Rec. Geol. Surv. Ind.*, Vol. XV, pt. 3, 1882, p. 181.

Later, in the year 1882, an analysis was made by Dr. Romanis on another sample, with the following result:—

Moisture	1·48
Volatile matter	26·58
Fixed carbon	65·12
Ash	6·82
	100·00

Quite recently, in 1907, Messrs. Gillanders, Arbuthnot and Company had a sample taken from the outcrop analysed, and have very kindly given me permission to publish the result, which I give below:—

Moisture	1·55
Volatile matter	13·00
Fixed carbon	79·90
Ash	5·55
	100·00

Carbon	76·60
Hydrogen	4·61
Sulphur	0·91
Oxygen	9·33
Nitrogen	1·45
Moisture	1·55
Ash	5·55
	100·00

The first analysis gives:—

Moisture	2·0
Combustible matter	91·5
Ash	6·5
	100·0

the second:—

Moisture	1·48
Combustible matter	91·70
Ash	6·82
	100·00

and the third:—

Moisture	1·55
Combustible matter	92·90
Ash	5·55
	100·00

These three analyses agree very closely in the amount of combustible matter in the coal, and differ only in the ratio of volatile matter to fixed carbon. From these results we turn next to some practical tests which were carried out at the request of the Government of Burma in the forges and locomotives of the Burma Railways and also on launches.[1] In the years 1882-1883 this coal was tested in the forges and found to give results which were superior to those at the time being obtained in the same forges by the use of Welsh steam coal. The next test was on an express locomotive where it was found that the coal contained too much fine material and dust; it was accordingly screened, and the best of it tested, when it was found impossible to keep up sufficient pressure of steam to run the train to its scheduled time. A second trial was made on a slow local train which proved that the train could be run, but that a much larger quantity of this coal was consumed over a given distance than of the coal ordinarily used. A trial on a steam launch showed that the pressure of steam could not be kept up by this coal. For these apparently contradictory results there must be some explanation. This explanation is apparently given by the high percentage of fixed carbon in the coal. The coal itself is a bright splintery coal, of low specific gravity, and is more of the nature of anthracite than ordinary coal, it is also much slickensided and does not coke on burning, all of which make it very difficult to burn under the conditions used for ordinary coal. To burn properly a forced draught is required, and very careful firing is necessary in order to keep a thin even covering; any approach to banking will spoil the fire at once and the steam pressure in the boiler will fall. This is the probable explanation of the apparently contradictory evidence given by the analyses and the working tests. In the steaming tests I have no doubt that the coal was used as if it was an average coking coal, and that no modification of the usual mode of burning was tried. In the forges where coking is not necessary, and a good forced draught is used, it was found to be better than Welsh steam coal. It should probably prove to be an excellent fuel for suction gas plants, such as are now used in large engineering undertakings both in Europe and America, but which do not seem to have been adopted to any extent yet in India or Burma.

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[1] This and the information immediately following is derived from correspondence on the files of the Government of Burma, Revenue Department, 1882-84.

The main drawback to the coal itself is its friable nature, and the small state of division in which it is obtained; the fine material could, however, be used with advantage for making briquettes, for which there should be a ready outlet as fuel. Materials for the manufacture of the briquettes might be obtainable from the residual products of the oil refineries.

The difficulties of working the coal are many. The seam is thin and dipping steeply. The coal itself is much slickensided, and has evidently been subjected to much crushing and movement, which is the probable explanation of the high percentage of fixed carbon in the coal. The country in which the seam occurs is much contorted, and composed of exceedingly hard rock, often indurated with silica, and consequently the cost of sinking a shaft would be considerable. The outcrop is situated close to the main fault which separates the western region from the eastern region, and is also situated close to the place where this main fault is itself faulted and shifted. Therefore the extent of the crushing and contortion to which the seam has been subjected must be considerable and the seam is not likely to be dipping underground in any definite plane, but is most probably irregularly contorted and in places slightly faulted. All supplies have to be brought from Kywezin, some six miles away, and during the dry weather there is no water in the locality. In the year 1882, when the Government of Burma were working this coal, a well was sunk in the dry stream bed but no water was obtained. It would not be a difficult matter however to pump water from the stream at Kywezin, which I understand is always running. During the latter half of the wet season until Christmas the locality is most unhealthy. In 1882-1883 the Government of Burma found it a very serious problem to obtain hired labour, and an experiment was made to work the mine by convict labour. The convicts were all withdrawn in December owing to the general sickness prevalent among them, both native guard and prisoners, without exception, suffering from fever. This, I think, would prove the most serious drawback to the proposition of working the coal, as the area over which coal occurs is too small to admit of much clearing of the jungle, and the amount cleared would have little effect on the unhealthiness of the locality owing to the dense jungle which covers the Yoma and completely surrounds this locality. As to the question of transport Messrs. Bombay, Burma Company have recently made a rough cart road from Mezaligon railway station to the coalfield, which, on a rough estimate, is twenty miles distant. If the working of this coal seam is ever seriously undertaken however, it would be an easy matter to lay a light tramway connecting the coalfield with Mezaligon. In addition to the coal, profit might be made by supplying road metal from the Negrais region, the rocks of which I will review below under the heading of road metal.

Hlemauk Outcrop

The outcrop of coal is about four miles west of Hlemauk in the bed of a stream, right by the main fault which separates the western Negrais from the eastern region. The seam is only twenty inches in thickness and the coal seems of very poor quality. It is dipping east 15° south at 40°. It contains a very large percentage of iron pyrites, sheets of which can be seen on the faces of the coal. It is extremely difficult to burn in an open fire, and on burning gives off strong fumes of sulphur dioxide. This outcrop is not worth further exploration.

Kyibin Outcrop.

North of the village of Kyibin is a thin band of impure carbonaceous shale, which runs north for some miles and can be met with in the several small streams which run east and west between Kyibin and Hlemauk. It seems to be the same seam that crops out at Hlemauk, but if so, it is here very much more impure, and is quite worthless. To the south near Wadawkwin it is traversed by the serpentine intrusion and becomes locally converted into impure graphite.

2.—Petroleum.

General Remarks.

During the two years previous to my visit to the district a large number of prospecting licenses for oil had been taken out, and for this reason I have, for convenience of description, split up the district into areas, and will deal fully with those which have been largely taken up or applied for. The reason for this rush to obtain oil concessions in the district is somewhat obscure. So far no one has obtained any oil in the district; nor has any important tract been taken up by one of the leading oil companies such as might induce smaller companies, who do not employ geologists, to apply for concessions surrounding, or bordering on, the area taken up by the bigger company. Up to the time of my visit no one had attempted any boring or drilling operations to prove in any way or to develop their concessions.

Suitability of the rocks for storage of oil.

Before going into detailed descriptions of the different areas, I will first review from the point of view of their oil-bearing possibilities the different series of rocks which crop out in the district.

In a previous paper I pointed out that the main petroliferous zone in Burma appears to be on the horizon of the Kama clay, which belongs precisely to that portion of the geological sequence which is absent from the Henzada district. I do not deny that oil may not be found at other horizons, and indeed oil seepages have been observed in Burma amongst rocks of older age. Nevertheless the zones adjoining the upper limit of the Prome series are, so far, the only ones that have yielded oil in commercially workable amount.

With regard to the possibilities of obtaining oil the Akauktaung beds may be dismissed at once, as nowhere south of Thayetmyo have they been found to contain oil; the absence of shales or other impervious beds amongst them precluding the possibility of any oil being stored in them even if they were at any remote time petroliferous. Also there is no anticlinal structure developed in them in the district. Under the Akauktaung series occur the Sitsayan shales, also non-petroliferous, for the exactly opposite reason that they are completely impervious and do not contain any sand beds such as are necessary to store the oil. In a previous paper I pointed out that the Sitsayan shales were non-petroliferous in Prome and South Thayetmyo.

The series of beds which crops out in the district under the Sitsayan shales is the coal-bearing sandstone series, which has nowhere any indications of being petroliferous, and which is everywhere dipping steeply to the east, thus having no suitable structure for storing oil even if it were petroliferous.

The western region contains no reported indications or seepages of oil and owing to its indurated condition is not likely to do so.

The Pauktaing area.

This area consists of the faulted anticline in the Sitsayan shales, which is situated to the west of Pauktaing. It can hardly be considered to be an anticline, but should be considered as an area of Sitsayan shales with an important fault running through the middle of it in approximately a north and south direction. This main fault has the downthrow to the east. East of it the beds are all dipping to the east, and west of it the beds are all dipping to the west. In the north-west corner of the area it is traversed by two cross faults which meet on the main fault at the large mud volcano called Bwettaung. The direction of the main fault is marked by a line of mud volcanoes, two to the north of the one mentioned above and one to the south of it.

I think then that there is little probability of oil in this region. The Sitsayan shales are themselves barren of oil, the rocks which underlie them are not covered conformably and therefore do not possess the same structure as that shown by the Sitsayan shales, and the centre of the area which divides the easterly-dipping beds from the westerly-dipping beds is a large fault, which in itself is sufficient to have destroyed the petroliferous value of the area, if indeed it ever possessed any.

The Petyi Area.

This area consists of the syncline in Akauktaung grits which is situated to the north of Petyi, and parts of the alluvial country to the south of Petyi; it can be dismissed in a few words. The Akauktaung grits are non-petroliferous, and synclinal structure is the most unfavourable that can be selected for the storage of oil. The Sitsayan shales which underlie the Akauktaung grits are not conformable with them, but show a synclinal structure and are non-petroliferous; the beds which underlie the Sitsayan shales are also covered unconformably. As there is not the slightest surface indication of oil in the area it may be taken for granted that it is not worth drilling, as there is no indication of any possibility of oil being present.

A section across these two areas is given on Plate 23.

The Yenandaung Area.

This area is situated to the east of the village of Yenandaung, and contains the exposure of limestone which forms the hill called Tondaung and the small exposure of shales to the east of it. Surrounding this outcrop the area is covered and concealed with plateau gravel deposits. The centre of the area is occupied by a fault running approximately north and south, the same which cuts through the

Pauktaing area, which has been shifted to the west by the cross faults which run just south of Petyi. The structure is the same as that discussed in the Pauktaing area. The limestone is dipping to the west and the shales east of the fault are dipping to the east. West of the limestone outcrop, and just at the foot of it, is a small outcrop of Akauktaung grits showing through the plateau gravels. A section across the area is given on Plate 23. The limestone outcrop is cut off on the south by a cross fault which runs south of Kyaukpazat and passes through Yenandaung village. At the south of the limestone outcrop, and approximately on the junction of the two faults, is a water spring and gas outlet which is marked on the maps as an oil spring. At the present time no trace of oil is visible in the spring. The area is no more favourable for oil than the Pauktaing area, any value which it may at some remote time have possessed having been utterly spoiled by the faulting which has taken place.

The Hngetkyi-Magyigon Area.

This area is situated around the villages of Hngetkyi and Magyigon and is similar in structure to the Yenangdaung area. The centre is occupied by the same north and south fault which traverses the Yenandaung area, the beds to the east of the fault dipping in an easterly direction and the beds to the west of it dipping in a westerly direction. There is no indication of any anticlinal structure and though the age of the beds is somewhat obscure there is no doubt that most of them belong to the Sitsayan shales. The exposure is much covered up with Plateau gravel, and there are two mud volcanoes situated on the fault, one to the north of Hngetkyi called Bwettaung, and a larger group of them south of Magyigon on Sabwettaw hill. There is no indication in this area that there is any underground storage of oil, for which the structure is most unfavourable.

The Kwingauk Area.

South of Kwingauk a large concession has been taken up which is situated for the most part on Plateau gravel. Towards the west of the area where it borders on the main fault separating the western region from the eastern region of the district, the strata which lie under the Plateau gravel deposits are seen. They consist almost entirely of the coal-bearing series of sandstones and are always seen to be dipping towards the east. There is no evidence of the presence of oil-bearing rocks nor is there any evidence of anticlinal structure.

That is to say, there is no evidence which would point to the fact that oil occurs within the area.

Except in the areas discussed above, there are in this district no indications of the presence of oil, nor any spots where experimental boring might be tried.

3.—Graphite.

A small deposit of graphite occurs west of Wadawkwin where a carbonaceous shale is altered into an impure graphite, and graphite schist, by contact with the intrusive mass of serpentine. The deposit is of small extent and does not seem to be of any economic value. North of this and close to Kyibin is another small deposit of more impure graphite, where the same carbonaceous seam is metamorphosed by the serpentine boss situated to the north of the Wadawkwin intrusion.

4.—Iron Pyrites.

Iron pyrites seems to be common in the Negrais region, and several samples were brought to me from different spots situated in the hills. Nowhere have I seen any deposit of pyrites important enough to be of any economic value, the mode of occurrence being in small isolated crystals scattered through the rock.

5.—Road Metal.

There is a demand at present in the district for road metal, and recently quarries have been opened in the outcrop of Akauktaung grits running through Pauktaing. This stone is a coarse grit fairly fossiliferous, cemented together with carbonate of lime. The outcrop is much weathered into loose iron-stained sand and grit, owing to the solution of the calcareous cement by percolation of rain water. It is on digging out this loose sand that small lumps of still unaltered stone are found. These unweathered portions seldom exceed a few feet in thickness and length, and consist of hard blue-grey rock. It is totally unsuitable for road metal, as the carbonate of lime cement will quickly dissolve out under the action of rain water, leaving a fine loose sand. The best stone in the district for road metal is that which occurs in the western region; the hard indurated sandstones, which are infiltrated with silica, being intensely hard and at the same time offering great resistance to the weathering action of the rain.

EXPLANATION OF PLATES.

PLATE 22.—Geological map of the area between the Henzada district and the previously mapped Prome district. 1 inch = 2 miles.

,, 23.—(*a*) Section east and west through Kyangin. 1 inch = 3 miles.

(*b*) Section east and west through Tondaung. 1 inch = 3 miles.

,, 24.—Geological map of the northern and southern portion of the Henzada district. 1 inch = 4 miles.

THE GEOLOGY OF THE LONAR LAKE. BY T. H. D. LATOUCHE, B.A., F.G.S., *late Officiating Director, Geological Survey of India.* WITH A NOTE ON THE LONAR SODA DEPOSIT. BY W. A. K. CHRISTIE, B.SC., PH.D., *Chemist, Geological Survey of India.* (With Plates 25 to 28.)

THE GEOLOGY OF THE LONAR LAKE.

T. H. D. LA TOUCHE.

THE Lonar Lake is situated in Lat. 19° 58′ 45″, Long. 76° 34′, in the Buldana District of Berar (otherwise known as the Hyderabad Assigned Districts), in the Central Provinces of India. The most convenient way of reaching it is from the Great Indian Peninsula Railway station at Malkapur, whence a metalled road runs through Buldana to Mehkar, a distance of about 70 miles, situated about 12 miles to the north of Lonar, and connected with it by a village cart track. The place may also be reached from Jalna, a town in Hyderabad territory on the Nizam's State Railway, but the road, though much shorter than that from Malkapur, is in a very bad state of repair. The Hindustani name Lonar signifies a salt-pit.

Previous Accounts.

Several accounts of the lake and of its peculiar surroundings have been published, and so far as its physical features are concerned leave little to be said. The first occasion on which it appears to have been seen by a European was in August 1823, when Cornet J. E. Alexander came unexpectedly upon it in the course of a journey through Berar, and communicated a vivid and picturesque description of it to the Edinburgh Philosophical Journal, together with a view of the lake taken from nearly the same point as the photograph shown in Pl. 27. "Beneath our feet," he says, "and at the bottom of a mighty chasm, lay a deep still lake, the waters of which were slightly ruffled by the breeze, and beautifully tinted by the rays of the setting sun. It was of a circular form, and

1824. J. E. Alexander, Edin. Phil. Journ. Vol. XI, p. 308.

hemmed in by an amphitheatre of cliffs, which rose, in precipitous ridges, to an elevation of about 500 feet from its shores, environing it on every side, and preventing completely the egress of its waters. The rocks which surround this interesting piece of water cannot come under the denomination of hills, for they do not, in any part, tour above the level of the surrounding country; they merely form the sides of an immense caldron, the circumference of which is about three miles. In short, the scenery, taken collectively, is a small counterpart of the celebrated Lake Avernus, differing from it in this respect, that no river

'Laco se condidit alto.'

In lieu of which, a solitary spring of some magnitude dashes in a small cascade from the eastern face of the rocks, and pours its waters into an artificial stone tank, surrounded by temples and pagodas, dedicated to the god Siva; issuing from which it forms another cataract, of about 50 feet in height, before it rushes on its turbid course to join the waters of the lake." He also gives a rough analysis of the water, which was found to contain 37·52 parts of salt, consisting of the 'muriates' of soda, lime, and magnesia, in 100; and a list of the uses to which it was put. These were:—

(1) "In cleaning the shawls of Cashmere, an alkaline soap being manufactured out of the muriatiferous clay, ... and sent to that distant region;"

(2) As "an article of food by Musselmen;"

(3) As "aqua-regia in the solution of gold;" and

(4) Medicinally.

About six years before his visit the annual revenue from the sale of the salt amounted, he states, to three lakhs of rupees, but the disturbances caused by the Mahratta war had led to the decay of the bunds or dams which prevented rain-water finding its way into the depression, and only a small portion of the bed of the lake was dry in the hot season. For the same reason the village of Lonar, which formerly was the resort of merchants from every part of India, was almost dilapidated.

1839. A. B. Orlebar, Trans. Bombay Geogr. Soc. Vol. II, p. 35.

The theory of the origin of the depression put forward by Professor Orlebar in 1838 does not seem to have met with the attention it deserves, for though the forces that produced the effects described are not specified, his explanation seems to me to be more in accordance with the facts observed than any other that has been suggested. Arguing from the inclination of the axes of the columnar prisms developed in the trap towards the middle of the basin, he concludes that the strata must have been elevated about its centre, and proceeds :—" When the bed had been heaved up in the crown *a*, *b*, *c*, (see the rough diagrams, figs. 1 and 2, reproduced from Professor Orlebar's work), the central part at *b*, on the force of upheaving subsiding, would again sink until it formed a wedge at *d*, and so preserved the rock in an inclined position." (In the published diagram the letters are not inserted in the second figure, but it is evident that they should have been placed as shown in the reproduction, for they cannot refer to the plan, fig. 1). He describes the rock as an amygdaloidal trap, and shows that the hollow could not have been the crater of an active volcano, " for the amygdaloidal cavities are all round and not at all elliptical which they must have been had they been formed in a rapidly flowing stream of lava. And also the crystals are generally arranged in a star-like form, as if in a state of quiet they had been able to submit to their mutual attractions, which they could not have done had they been in a fluid rushing fresh from a crater."

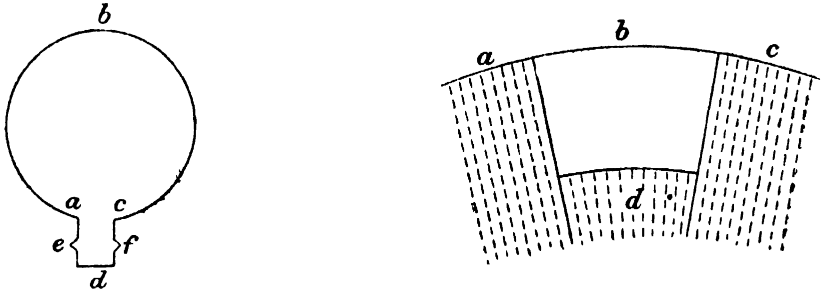

FIG. 1. FIG. 2.

Diagrammatic plan and section of the lake basin (after Prof. Orlebar).

FIG. 1. *a*. *b*, *c*, rim of basin ; *d*, ravine ; *e*, *f*, lateral ravines.

FIG. 2. *a*, *b*, *c*, elevated surface ; *d*, column of rock that has been let down.

1840. J. G. Malcolmson, Trans. Geol. Soc. London, 2nd Ser. Vol. V, p. 562.

In the course of a paper " On the Fossils of the Eastern Portion of the Great Basaltic District of India", Mr. J. G. Malcolmson gives an account of the Lonar Lake. He says that " it never seems to have been an active eruptive vent, as no scoriæ or lava currents can be traced around its margin, which is too distinct and unaltered to admit of any probability of these having been subsequently removed by denudation. A certain degree of forcible elevation was sustained by the margins of the lake, when the explosion or subsidence happened from which the great depression took its origin." Mr. Malcolmson also discusses the origin of the salts in the lake water, which forms the subject of the second part of the present paper.

1848. T. J. Newbold, Journ. Roy. Asiatic Soc., Vol. IX, p. 40.

Captain Newbold, in his Summary of the Geology of Southern India, quotes Malcolmson's account of the lake, and gives a section of it, with a view taken from the same point as Alexander's. He thinks that the hollow was formed by subsidence like the Val del Bove, or "by a great gaseous extrication."

1853. H. J. Carter, Journ. Bombay Br. Roy. Asiatic Soc., Vol. V, p. 334.

Dr. H. J. Carter, in his comprehensive Geology of India, quotes an account furnished to him by Dr. Bradley of the Hyderabad Contingent, who had apparently written a memoir on the lake, of which I have been unable to obtain a copy.[1] He thinks that the hollow was the crater of a volcano, and that the ravine on the north-east side marks the vent through which the lava escaped. The sides of this ravine, according to Dr. Bradley, are "burnt and semifused by the passage of the molten rock."

1855. G. Buist, Edin. New Phil. Journ., Vol. I, p. 260.

Dr. G. Buist, writing on the Principal Depressions in the Surface of the Globe, mentions the Lonar Lake, and says that it appears to be the crater of an extinct volcano, "lava being in abundance at no great distance."

1857. G. Smith, Madras, Journ. Lit. and Sci., New Ser., Vol. I, p. 260.

In an account of the lake, prepared for the information of the Committee of the Madras Exhibition in 1857, Dr. Smith describes its appearance and surroundings, and gives particulars of the different varieties of salt derived from its waters and the methods of collecting them. He says that there are two saline springs near the centre of the lake, which never become dry even in seasons of extreme drought; but he may have been mistaken, as he only saw the supposed springs from the shore. At any rate nothing of the kind exists now. He gives statistics of the five different kinds of salt produced, but in his time the lake had not been regularly worked since the year 1836, when 2,136 kandis (about 460 tons) of salt were raised, valued at Rs. 60,081, yielding a nominal revenue of Rs. 45,000 to the Native Government. He gives Dr. Bradley's theory of the origin of the depression, but thinks that the surrounding lava is too compact to have issued from a subaërial volcano, and suggests that it may have been submarine. Dr. Smith's paper is followed by a report by Mr. J. E. Mayer, Professor of Chemistry, Madras, on a chemical examination of the salts of the lake.

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[1] W. H. Bradley. *Pharm. Journ.*, 12, p. 515, 1853 (W. A. K. C.)

1870. W. T. Blanford, Records, Geol. Surv. Ind., Vol. I, p. 62.

Mr. W. T. Blanford visited the lake in 1867, during the course of a traverse from Poona to Nagpur, and was convinced that the hollow owes its origin to volcanic action, though he remarks that there is a total absence of everything which in general characterises a volcano. He mentions a raised rim which is to be seen on the eastern, southern, and western sides, composed of huge blocks of trap, and suggests that the bulk of the material ejected was reduced to fine powder, scattered over the surrounding country, and removed by subsequent denudation. He could find no evidence of the lava flows mentioned by Dr. Bradley, and emphasises the fact that no dykes were observed. The trap beds dip away from the edge of the hollow generally but irregularly, and appear to owe their dip entirely to disturbance.

1879. Medlicott and Blanford, Manual, Geology of India, Part I, p. 379.

The authors of the Manual of the Geology of India ascribe the origin of the depression to a singularly violent volcanic explosion, unaccompanied by the eruption of melted rock, and consider that the date of its formation was long posterior to the epoch of the Deccan trap, "for the hollow appears to have been made in the present surface of the country, carved out by ages of denudation from the cretaceous lava flows," and that it was of comparatively recent origin.

1881. V. Ball, Manual, Geology of India, Part III, Economic Geology, p. 493.

Mr. Valentine Ball, however, in the third part of the same work, thinks it possible that the hollow was not in any way of volcanic origin, but that it was caused by subsidence due to the giving way of the roof of a large cavern in calcareous rocks underneath. Limestone rocks belonging to the Lameta or infratrappean formation are known to underlie the basalts at certain localities; but there is more than one serious objection to this theory. Firstly, the perfectly circular shape of the basin; secondly, the slight thickness of the Lameta limestone in any of its known outcrops, rarely amounting to as much as 100 feet, whereas the Lonar basin is at least 300 feet deep; and thirdly, the nature of this limestone, which is not suitable for the formation of open caverns. Fourthly, Mr. Ball's theory does not account for the general dip of the lava flows away from the edge of the hollow; and finally, the fact that the floor of the hollow lies well below the level of any of the scarps in the neighbourhood renders it difficult to see how a cavern of the size required, whose floor must have been at least 600 feet below the surface, could possibly have been excavated.

1884. R. G. Smythe, MS. note.

In a MS. note furnished by Lieutenant-Colonel R. G. Smythe, Superintending Engineer in Hyderabad, to Dr. William King, he follows Mr. Ball in thinking that the crater is due to subsidence, "and by no means to volcanic action;" and in order to account for certain anomalous features in the rise and fall of the water of the lake, he supposes that it is introduced through what he calls 'infiltrating strata,' and that when the water reaches a certain level it escapes through another set of so-called 'outlet strata.' No signs of such porous strata can, however, be detected at any part of the enclosing walls, and as the outlet channel, according to a diagram given by Colonel Smythe, is supposed to issue at the base of the cliffs, it must lie well below the saturation level of the surrounding country, and no outflow from the lake could take place through it. One point of some importance established by Colonel Smythe's elaborate enquiry is that a hard rocky floor exists at a level of about 30 feet below the surface of the water when at its lowest.

In his reply Dr. King suggests that the rise and fall of the lake depend on the general saturation level of the surrounding country.

1906. R. D. Oldham' Records, Geol. Surv. Ind.' Vol. XXXIV, Part 3, p. 147.

Mr. R. D. Oldham, describing a series of hollows in the Lower Chindwin District of Upper Burma, which he found to be explosion craters of undoubted volcanic origin, rejects the theory of subsidence, and supposes that, as in the case of the Burmese craters, the bulk of the material ejected was scattered in a thin layer over the surrounding country, and that the rim which was originally thrown up, being situated on the very edge of the crater, was especially exposed to denudation, and has been largely removed.

1909. F. J. Plymen, Indian Trade Journal, Vol. XIV, p. 228.

A report published in the *Indian Trade Journal* by Mr. Plymen, Agricultural Chemist to the Victoria Institute, Nagpur, deals entirely with the composition of the salts derived from the lake and their economic value, and will be noticed in the second part of this paper.

Description of the Lake Basin.

On the occasion of our visit, in March 1910, the water in the lake was almost at its lowest, and I found by sounding that it was in no place more than two feet deep. The bottom of the hollow is practically flat in the centre, and covered, up to the level reached by the water in the rainy season, with a thick deposit of black mud, shelving so gradually that it was necessary to wade out to a considerable distance before the depth was sufficient to float a light canvas boat, drawing less than three inches of water. Surrounding this ring of mud, which is shown by stipling in the plan (Pl. 27 and 28), is a circular strip of ground covered with coarse grass, which may be submerged in seasons of exceptional rainfall. From the edges of this the ground slopes up more rapidly on all sides to the base of the surrounding walls, which have a very regular slope of about 40 degrees, and rise to an even height of about 300 feet above the lake. The diameter of the hollow thus formed is about a mile and a quarter, measured across from crest to crest, and about three-quarters of a mile at the bottom. On the north-east side, close to the village of Lonar, a rocky ravine worn through the lava by the waters of a spring which issues from the solid rock only a few feet below the crest, and is built over by the temple seen in the foreground of Pl. 26, gives access to the lake, and at the mouth of this a semicircular delta, affording the only space within the basin capable of cultivation, has been formed. The rocky sides of the hollow, and the sloping talus at their base, are well wooded, and though steep may be climbed at almost any point. The remarkable symmetry of the drainage channels, dry except at times when rain is actually falling, may be noted, and is no doubt the cause of the uniformity of the angle of slope of the encircling walls.

The surface of the surrounding plateau slopes gently away from the edges of the hollow, corresponding with a quaquaversal dip of the lava flows, except on the north-eastern side, where the village of Lonar stands on slightly higher ground. A ring of low, mound-like elevations, strewn with loose blocks of lava, stands upon the very edge of the crater, forming the 'raised rim' mentioned by Mr. Blanford, and supposed by him and by Mr. Oldham to be the relics of the material ejected from it; but it appeared to me that the appearance of a raised rim was merely due to the peculiar character of the weathering of the uppermost layer of trap; that, in fact, the mound-like appearance of the 'rim' is caused by the cutting back of the heads of the numerous rain-water channels that score the face of the walls, and that the blocks of lava with which they are strewn have been weathered out *in situ*. If this is the case, the main argument for supposing that the hollow is the result of a single violent explosion becomes invalid, and as this theory seems to be untenable on other grounds also, we are driven to look for some other explanation that will account for the formation of the depression.

The chief objection to the acceptance of the explosion theory is, in my opinion, the absence of any indication whatever of a funnel or pipe, through which the explosive forces could have acted in the floor of the basin, which is absolutely level, and the information communicated to Dr. King by Colonel Smythe, that the lake silt rests upon a level floor of solid rock. It does not appear, indeed, that Colonel Smythe put down borings in the bed of the lake itself in order to prove this, but if there was any crater-like opening in the floor, it would surely manifest itself by a depression of some kind towards the centre of the lake. A local subsidence of the superficial layers of trap seems to be the only alternative, and it remains to discuss the means by which such a subsidence could have been brought about.

The suggestion put forward by Mr. Valentine Ball, that a subsidence was caused by the falling in of a huge cavern in the underlying Lameta limestone, if it exists at this locality, may be dismissed for the reasons that I have already given; and the only alternative seems to be the theory outlined by Professor Orlebar, namely, that the superficial layers of trap already poured out may have been locally elevated by some force acting from below, and afterwards let down on the withdrawal of the elevating force to a lower level than they previously occupied. Taking these events in order, the elevation may have been produced, in my opinion, in either of two ways: (I) by what may be called an 'abortive explosion,' that is to say, that a sudden inrush of steam or other vapour from below raised the superficial strata slightly, but was not sufficiently powerful to hurl the cover of the cavity so formed into the air; or (II) that the occurrence was of the nature of what may be called an 'incipient laccolite,' in other words, that a quantity of molten lava was injected from below, through fissures that did not penetrate to the surface, and forced up the already consolidated layers in the dome-shaped manner peculiar to such phenomena. In either case a kind of 'blister' would be formed, supported in the one case by steam or vapour under pressure, and in the other by molten rock. We have only to suppose then that some lateral outlet suddenly opened, and allowed the escape of the steam or lava, leaving the centre of the dome unsupported, when it would naturally give way by fissuring symmetrically round the centre, allowing a broad column of solid rock to sink into the cavity beneath, and at the same time wedging up the sides. This conjecture is illustrated by the two diagrams annexed (figs. 3 and 4) in which the space supposed to be occupied by the injected material is shaded.

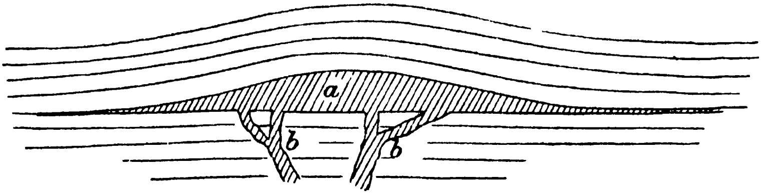

FIG. 3.
a, cavity filled with steam or molten lava injected through the fissures *b*, *b*.

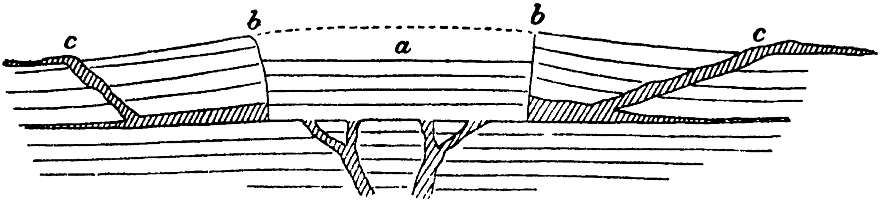

FIG. 4.
a, lake basin; *b*, *b*, fractures; *c*, *c*, lateral fissures through which the material filling the cavity escaped.

The existence of a circular fissure at the base of the walls encircling the lake basin, such as would have been formed under the conditions that I have supposed to obtain, appears to be indicated by the influx of fresh water from springs on all sides of it. One of these supplies a well, in which the water stands at a much lower level than that of the lake, though the well is so close to the southern edge of the lake that it must be surrounded by salt water when the lake is full, and yet supplies drinkable water at all seasons. The water in this and in certain other springs appears to issue from the rocky floor, but some of the fresh water that renders the grassy zone swampy may be derived from the talus slopes at the foot of the cliffs, where it is stored during the rainy season. It seems, however, to issue in larger quantities than such a source would be likely to supply, seeing that the small rivulets that descend the walls only carry water while rain is actually falling, and that most of it flows directly into the lake. The present slope of the encircling walls need not hinder the acceptance of the conjectures now put forward that they were originally caused by a vertical fissure, for it is evidently that of the angle of rest of the débris furnished by the weathering of the cliffs, and is entirely due to denudation.

The principal fact to be ascertained, in order that we may decide which of the two rival theories put forward, of explosion or subsidence, is the more worthy of acceptance, appears to be whether an orifice through which the explosive forces could have acted does actually exist; or whether the floor of the hollow consists of a level platform of solid rock. This can only be done by making a systematic series of borings which need be of no great depth, and could easily be put down by hand even in the portion covered by the water of the lake, at any rate in the dry season. Besides clearing up the difficulties that surround a discussion of the physical origin of the hollow, a series of borings would be necessary in order to find out what is the true economic value of the salts contained in the basin; for it is probable that, as the hollow has been gradually silted up, successive layers of the salts that are now found in the lake water have been deposited, and might be recovered by a system of dredging and lixiviation: and if further attempts are to be made to utilise the salts of the lake in any way, they should be preceded by a thorough investigation of its possibilities, carried out in the manner indicated.

NOTE ON THE LONAR SODA DEPOSIT.

W. A. K. CHRISTIE.

Method of manufacture.

THE soda of the Lonar basin is contained partly in the shallow lake in the middle of the depression and partly in the alkaline mud which covers the whole floor of the hollow. Crude soda has been recovered from the lake water for centuries. The methods used must have varied considerably from time to time, for the descriptions of them by various observers are by no means concordant. The following particulars were obtained from the present lessee of the lake and his overseer. When the lake water has receded by evaporation a whitish incrustation known as "bhuski" is left on the shores. This is contaminated with decomposed algæ and other organic matter, besides containing when collected a large percentage of earthy impurities. The product is now unsaleable and its recovery has been discontinued. Wooden stakes are fixed in the lake-bottom at intervals determined by experience; when the water has evaporated so far as to leave the outermost stake on dry land, the first layer of crystals, known as "papri," is collected by hand from the bottom of the lake. This generally takes place about May when the lake is about six inches deep. When the brine has retreated as far as the next stake, "khuppal" is similarly collected and "dulla" after a further retrogression. The deposit that subsequently forms is called "nimak dulla" or "dulla nimak." The composition of the various products is shown in the table below, taken *verbatim* from a report by F. J. Plymen.[1]

Composition of the products recovered.

100 parts of the air-dried substance contain—

	Dulla.	Khuppal.	Dulla Nimak.	Nimak Dulla.	Pipadi or Papri.	Bhuski.
Insoluble mineral matter . .	1·89	4 73	2·41	2·15	4·49	18·69
Insoluble matter lost in ignition	0·18	0·76	0·16	0·06	0·52	2·14
TOTAL Insoluble Material .	2·07	5 49	2·57	2·21	5·01	20·83

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[1] *Ind. Trade Jour.*, 14, p. 229, 1909. Analyses are also given by J. G. Malcolmson, (*Trans. Geol. Soc.*, 2nd Ser., V, p. 562, (1840)); R. Reynolds, (*Pharm. Jour.* 12, p. 517, (1853)); J. E. Meyer, (*Mad. Jour. Lit. Sci.*, New Ser., I, p. 16 *et seq.*, (1857)); J. B. Lyon, (Gazetteer of the Haiderabad Assigned Districts, p. 25, Bombay, (1870)); and W. Wallace, (*Chem. News*, 27, p. 205, (1873)).

	Dulla.	Khuppal.	Dulla Nimak.	Nimak Dulla.	Pipadi or Papri.	Bhuski.
Soluble substances including—						
(*a*) Carbonic acid present as carbonate . . .	19·47	10·00	13·72	4·84	9·62	13·58
(*b*) Carbonic acid present as bicarbonate . . .	17·38	9·52	13·72	4·49	9·02	14·42
Sulphates as sulphur trioxide	None.	0·70	0·10	0·08	0·87	0·21
Silica	0·17	0·40	0·33	0·26	0·05	0·30
(*c*) Chlorine . . .	Trace.	22·73	14·72	43·25	25·48	2·03
Oxides of iron and alumina	0·46	1·21	0·64	0·65	1·47	4·58
Calcium oxide (lime) .	0·13	0·24	0·24	0·16	0·26	1·35
Magnesium oxide (magnesia)	0·09	0·22	0·21	0·22	0·40	0·39
Soda (as sodium oxide) .	33·65	35·17	34·42	44·54	33·36	26·15
Potash (as potassium oxide)	7·14	6·88	9·95	4·28	10·29	5·07
Moisture, water of crystallisation and organic matter	20·90	16·03	15·30	6·46	14·71	24·46
(*a*) Equal to sodium carbonate . . .	46·90	24·09	33·05	11·67	23·19	32·72
(*b*) Equal to sodium bicarbonate . .	33·18	18·18	26·09	8·58	17·21	27·53
(*c*) Equal to sodium chloride (common salt) . . .	..	37·45	24·25	71·11	41·99	3·35
TOTAL Carbonic Acid (Carbon Dioxide) . . .	36·85	19·52	27·44	9·33	18·64	28·00

Mineralogical character of the products recovered.

The products differ widely in composition, but the relative proportions of carbonate and bicarbonate of soda are very similar in them all. T. M. Chatard[1] has pointed out the similarity of this relationship in the deposits of many of the soda lakes of the world, and has suggested the restriction of the use of the term "urao" to a compound commonly found therein consisting of one molecule of carbonate with one of bicarbonate and two molecules of water of crystallisation ($NaCO_3$, $NaHCO_3$, $2H_2O$), a substance which he also prepared artificially.[1] The theoretical composition of this compound is—

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[1] *Bull. U. S. Geol. Surv.*, 60, p. 67, 1890.

Na_2CO_3	46·89 per cent.
$NaHCO_3$	37·17 „
H_2O	15·94 „

the ratio of sodium carbonate to bicarbonate in the samples whose analyses are given above is as follows:—

46·89 : 33·17 in dulla,
46·89 : 35·40 in khuppal,
46·89 : 37·02 in dulla nimak,
46·89 : 34·18 in nimak dulla,
46·89 : 34·80 in papri,
46·89 : 39·45 in bhuski,

the theoretical ratio for urao being 46·89 : 37·17. The amount of water found is in every case sufficient for the $2H_2O$ of the formula, the excess being presumably hygroscopic. Such errors as there are in the analyses probably affect but slightly the figures for Na_2CO_3 and $NaHCO_3$, which have apparently been determined directly, and the presumption would therefore seem justified that the products of the Lonar Lake consist mineralogically of the definite compound urao, mixed with varying quantities of common salt and other impurities.

Suggested improvements in manufacturing methods.

As the resources of the lake are very limited in extent (see p. 280) and the margin of profit on the sale even of pure products cannot be high on account of heavy freight charges to the nearest markets and of the cheapness of imported soda, any schemes for improved working of the deposit should involve neither large capital outlay nor high working charges. The most obvious method of purifying the crude salt is that suggested by J. E. Meyer[1] and W. Wallace,[2] namely, to dissolve them in water, evaporate the solution at boiling temperature until a large part of the sodium chloride had crystallised out, and then allow the concentrated liquor to deposit sodium carbonate crystals on cooling. Wood is scarce in these parts; the freight on coal is high and moreover the plant required for the operations would be expensive. It seems more feasible to make use of the natural advantages, firstly, of the situation of the lake, where solar evaporation is rapid, fairly constant, and costs nothing, and secondly, of the composition of the crude products obtained; for urao, which, as we have seen, is the carbonate-carrying component of the various salts recovered by simple evaporation, can be recrystallised unchanged.[3] These impure salts after being dissolved in dilute lake-water might be allowed to recrystallise, when a much purer product, approximating to pure urao in chemical composition, would be obtained on natural evaporation. The efficiency of the compound could be enhanced by some 40 per cent.—an important consideration in view of the high transport charges—by simple heating in a reverberatory furnace fed with wood, to remove the water and the bicarbonate excess of carbonic anhydride. Recrystallisation tanks might be constructed within the mud-grass zone, and with a lining of the finest clayey sediment of the lake-bottom would probably quickly become watertight with use. Wooden channels running from the level of the crystallising tanks on a gentle incline to two or three feet above the level of the lake-water at the shore could be used for conveyance of the water lifted by the native swing-basket method. The absence of appreciable quantities of sulphate in the brine considerably simplifies the work of recrystallisation, which would not be adversely affected by the great difference between day and night temperatures.

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[1] The name Trona is preferred by Dana and it certainly has priority over Urao—C. Bagge (Kongl. Vetenskaps Academiens Handlinger, xxxiv, p. 140, (1773)) having used it for a soda mineral from near Fezzan in Tripoli, which however he did not analyse. Klaproth's (Beitr. z. chem. Kenntniss d. Mineral-körper, III, p. 83 (1802)) analysis of a mineral also from the neighbourhood of Fezzan, and presumably the same, shows that it is not Na_2CO_3, $NaHCO_3$, $2H_2O$, but contains 35·9 per cent. of Na_2CO_3 and 46·0 per cent. of $NaHCO_3$. "Urao" was the term used by the indigenous inhabitants for a mineral recovered from the bottom of a small lake, south-west of Merida in Venezuela; M. de Rivero and J.-B. Boussingault's analysis (Ann. de Chimie, 29, p. 110, (1825), *cf.* also P. Faxar, id., 2, p. 432, (1816)) of this mineral agrees very closely with the formula Na_2CO_3, $NaHCO_3$, $2H_2O$, and as the name Trona has been somewhat loosely applied to carbonates of soda of varying composition, it seems advisable to follow Chatard in his preference for the term Urao.

Fresh water near the lake at the time of extraction is a scarce commodity; to effect solution of the impure salts recovered from the lake-bed in one season the dilute brine present in the lake after the rains at the beginning of the next season might be used, but it would probably be better to employ water from canals dug round the edge of the lake. A small experimental pit, 1·37 metres deep, 1·42 m. in diameter at the top and 0·46 m. at the bottom was sunk in the mud-zone, (see Pl. 28) 47·5 m. from the lake shore and the same distance from the edge of the mud-grass zone. The surface of the ground at this point was 20 c.m. above the level of the lake-water. Samples of mud taken at various depths showed a concentration of carbonate at the surface due to efflorescence and a tendency to a decrease in alkalinity with depth; this was probably fortuitous, as samples from a similar pit on the other side of the lake increased in alkalinity as the depth increased. Water containing the equivalent of 11·07 grammes of sodium carbonate per litre flowed in at first at the rate of 2·3 l. per minute. Sixteen hours later the water level was 48 c.m. below the surface of the ground and 0·15 l. per minute were flowing in. Water from the top had the same density and alkalinity as that from the bottom of the pit. An average sample contained 8·48 g. of CO_3 per l., of which 4·28 g. were present as bicarbonate and 4·20 g. as carbonate. As the lake-water is somewhat deficient in bicarbonate (see p. 283), the conditions for the formation of a good crop of urao[1] would be improved by the addition of this subterranean water with its high bicarbonate content. The water was much less concentrated (s. g. 1·025) than the lake-water (s. g. about 1·06) and — another point in its favour for recrystallisation purposes — the chloride content, 13·7 g. per l., bore a smaller ratio to the carbonate content than that of water from the lake. An examination of the water from a second pit showed it to be similar in composition though more dilute. It contained per l. 1·22 g. of CO_3 as carbonate, 1·16 g. of CO_3 as bicarbonate, and 4·47 g. of Cl.

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[1] *Mad. Jour. Lit. Sci.*, 1, New Ser., p. 20, (1857).

[2] Central Provinces District Gazetteers, Buldana District, p. 303. Calcutta. (1910).

[3] *Cf.* Chatard, *loc. cit.*, p. 58. H. N. McCoy and C. D. Test, (*Jour. Amer. Chem. Soc.*, 33, p. 473, (1911)), have worked out the conditions for recrystallisation from water containing no foreign substances.

Economic resources.

The area of the lake in March 1910 was 380,000 square metres (94 acres) and it contained 85,000 cubic metres of brine. The total amount of alkali in this, reckoned as sodium carbonate, is about 2,000 metric tons. This does not indicate of course all the alkali in the depression. The mud-zone, with an area of 725,000 sq. m. (179 acres) and an average alkalinity in the upper 1·5 m. corresponding to 0·26 per cent. of sodium carbonate, contains some 4,500 tons in this superficial layer. Without borings it is impossible to tell to what depths such mud persists, and much larger quantities may be stored below in the mud and the subterranean water. As the manufacture of soda is continued the value of the deposit will deteriorate, not only because the amount of carbonate removed in any one year will probably exceed that brought in, but because the mother liquors from the manufacture cannot be removed from the drainage area, and the brine from the extractor's point of view must deteriorate on account of this accumulation of chloride.

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[1] *Cf.* Chatard, *loc. cit.*, pp. 79, *et seq.*

Prospects of profitable working.

Formerly there was a local demand for the alkaline products of the lake for the manufacture of glass bangles and for cleaning and dyeing purposes. Stress of outside competition has, however, suppressed this demand, and until local industries requiring sodium carbonate create a local market, the products will probably have to compete in Bombay with imported soda. The question of the disposal of the salts already extracted and the future economic working of the lake's resources resolves itself into one of road and railway freights. The cost of transport of the salt from the lake shores is given by the lessee of the deposit as—

From lake shore to Lonar village	. 2·72	annas per cwt.
„ Lonar to Khamgaon station	. 9·07	„ „
„ Khamgaon to Bombay .	. 16·33	„ „
TOTAL	. Rs. 1-12-1	per cwt.

Plymen's figures for the best of the products ("dulla") show that it contains the equivalent of 68 per cent. of sodium carbonate. Taking soda-ash as imported into Bombay as containing 99 per cent. of sodium carbonate, and its value as Rs. 5-4 per cwt.,[1] the maximum value of the Lonar dulla—assuming that its price depends simply on the amount of sodium carbonate to which it is chemically equivalent—would be Rs. 5-4 $\times \frac{68}{99}$, *i.e.*, Rs. 3-9-8, leaving for all other charges Rs. 3-9-8—Rs. 1-12-1, *i.e.*, Rs. 1-13-7 per cwt. The assumption that the consumer is concerned only with the chemical efficiency of the product is of course not justified; the presence of 10 per cent. of impurities takes far more than 10 per cent. from its market value, and the user will always be ready to pay extra for a guarantee of purity, so that the figure Rs. 1-13-7 would in practice be much smaller. Were the quality of the manufactured products improved and the freight charges on the water and excess carbonic anhydride eliminated, the deposit might be profitably worked, but unless further investigation should prove the persistence of the alkaline mud to considerable depths, profitable manufacture can only be carried on in a small way.

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[1] Kindly communicated by Messrs. D. Waldie & Co., Calcutta.

Theories of the origin of the deposit.

The origin of the soluble salts in the bed of the lake has not given rise to so much controversy as the origin of the topography of the neighbourhood, but various theories have been advanced from time to time to account for their presence and composition.

J. G. Malcolmson.

J. G. Malcolmson[1] accounted for the occurrence of sodium carbonate on a theory of C. L. Berthollet based on the formation of this compound from a pasty mixture of sodium chloride, calcium carbonate and water. This theory has been applied in various amended forms with and without the intervention of carbonic acid to explain the formation of soda deposits in different parts of the world,[2] but the elimination of the calcium chloride necessarily produced and the origin of the sodium chloride or sodium sulphate which forms the starting point of these theories would, in the case of the Lonar Lake, present greater difficulties than those which now confront us.

G. Smith.

G. Smith[3] supposed the formation to be due to the action of the water of two saline springs in the lake-bed on the carbonate of lime found in other springs of the lake.

K. L. Mackenzie.

K. L. Mackenzie,[4] in a somewhat unscientific account of the lake, suggested the derivation of the salts from two openings towards its western side, whose areas he gave circumstantially as from 2 to 2½ acres and from 1½ to 1¾ acres.

F. J. Plymen

F. J. Plymen[5] regards it as "practically certain that the Lonar salts are derived from an unknown source in the bed of the lake," and points out that, were any quantity of alkali present in the feeder streams, the abundant vegetation would have died out. There is no evidence of springs in the lake-bed from which the salts might be derived, nor at the time of our visit were there any openings such as Mackenzie described. A careful survey showed no irregularities in the configuration of the bottom and an almost remarkable uniformity in the concentration of the brine and its temperature in all parts of the lake.

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[1] *Trans. Geol. Soc.*, 2nd Ser., 5, p. 564, (1840).

[2] An excellent summary and discussion of the various theories of the origin of soda deposits is given by Prof. R. Wegscheider in C. Doelter's Handbuch der Mineralchemie, I, pp. 144-163, Dresden, (1911).

[3] *Mad. Jour. Lit. Sci.*, 1, New Ser., p 2, (1857).

[4] Gazetteer for the Haiderabad Assigned Districts, p. 24, Bombay, (1870).

[5] *Ind. Trade Jour.*, 14, p. 228, (1909).

W. T. Blanford.

W. T. Blanford[1] held that the deposit was formed by evaporation of the stream water in the absence of an exit. This theory of simple concentration seems to account for most of the facts. Plymen's criterion of the absence of vegetation from the land irrigated by an alkaline stream does not hold for such dilute solutions as concern us; the water of the spring feeding the main stream in question, which irrigates the most fertile part of the lake shore, was found to be distinctly alkaline — it contained the equivalent of 0·30 g. of sodium carbonate per litre.

Composition of the lake-water.

The composition of the Lonar lake-water is as follows, the figures giving the results of two concordant analyses of an average sample compounded from nine samples taken from different parts of the lake on 12th March 1910.—

Cl	34·18	grams per litre.
CO_3	14·79[2]	,,
SO_4	1·24	,,
S	0·01	,,
SiO_2	0·34	,,
Ca	0·01	,,
K	0·09	,,
Na	33·21	,,

with traces of iron, aluminium, magnesium (less than 0·01 g. per l.), and borate.

The derivation of the various constituents.

The sodium carbonate.

The unweathered trap rock of the neighbourhood contains 1·74 per cent. of Na, 1·24 per cent. of K, 0·022 per cent. of CO_3, 0·023 per cent. of SO_4 and 0·037 per cent. of Cl. The presence of sodium salts is therefore easily accounted for, as the country rock contains 1·74 per cent. of sodium, and an unlimited supply of carbonic acid from the atmosphere and from percolating waters is available for the formation of carbonates. These waters charged with dissolved gases, in whose composition carbonic acid takes a much more prominent place than it does in the atmosphere, leach out the alkalies from the parent rocks as carbonates or bicarbonates, and unless these solutions meet with other metallic radicles in solution, whose carbonates are less soluble than those of the alkalies, they will reach their destination unchanged. Waters from wells and pools marked A, B, C, D, E, F on the map (Pl. 28) contained respectively 0·78, 0·38, 0·82, 0·51, 1·08, 1·18 g. of sodium carbonate per l.

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[1] *Rec. Geol. Surv. Ind.*, 1, p. 63, (1870).

[2] Carbonate 12·60, bicarbonate 2·19; Warder's method.

The potassium.

The very low content of potassium[1] in the lake-water, when contrasted with the relative abundance of this element in the trap, is remarkable. It is also remarkable in view of the high percentage of potash reported by Plymen in his analyses of the crystallised deposits. It should be noted, however, that W. Wallace[2] found only 0·18 per cent. of potash in dulla and 0·09 per cent. in papri from the Lonar Lake. Though the proportions of sodium and potassium in the earth's crust are approximately the same, sodium usually greatly preponderates in springs, rivers, lakes and the ocean. This is chiefly due to the fact that the insoluble products of rock decomposition, clays and soils are capable of fixing considerable proportions of potassium, and in this way far more potassium than sodium is removed from percolating solutions.[3]

The sulphate.

The presence of small amounts of sulphate in the lake-waters is not incompatible with their direct derivation from the trap rocks, which contain 0·023 per cent. of SO_4. In such a lake the decomposition of low organisms, which flourish when the lake is dilute and decay on its becoming more concentrated, reduces the sulphates to sulphides, which are quickly converted by atmospheric carbonic acid to carbonates, the sulphuretted hydrogen escaping into the air.[4]

The chloride.

The large proportion of chloride in the lake-water, when compared with the minute quantities found in the trap, presents a difficulty. The water from the principal feeder spring contains only 0·051 grams of Cl per litre. Any chloride, however, which does reach the lake, remains there; the sulphate, as we have seen, may be transformed to carbonate, and the carbonate must be to a large extent used up in precipitating as insoluble carbonates, salts of magnesium, calcium, etc., which enter from streams and springs, any chloride they may contain being left in solution. The chlorides, therefore, must increase at the expense of the carbonates. As F. W. Clarke[1] has shown, carbonate waters form the first stage in the evolution of an inland lake, chloride waters the last; in the Lonar Lake we have an intermediate type.

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[1] Determined by Dittmar and M'Arthur's method.

[2] *Chem. News*, 27, p. 205, (1873).

[3] F. W. Clarke: *Bull. U. S. Geol. Surv.*, 330, p. 107, (1908).

[4] *Cf.* E. Sickenberger: *Chem. Zeit.*, 1892, p. 1691, (quoted by G. Lunge: Sulphuric Acid and Alkali, II, p. 67, London, (1909).

It is probable that the chlorides are derived to a considerable extent directly from the sea. According to the Climatological Atlas of India,[2] strong westerly winds blow steadily from the coast towards Lonar during the hot weather and continue unabated throughout the rains.

The importance of the transport of salt by wind far inland is now being more generally recognised. J. Joly, for instance, in his latest calculation of the age of the earth[3] has largely increased his previous correction for wind-borne salt. The inadequacy of the former allowance was insisted on by W. Ackroyd[4] and more recently by H. S. Shelton,[5] who suggests that 90 per cent. of the chlorine in river waters is derived from the sea. Farther north in India, too, it has been shown directly[6] that considerable quantities of salt are carried from the Rann of Cutch by the south-west winds of the hot weather and that rain which falls far inland at the beginning of the monsoon is much more heavily charged with salt than was supposed.

EXPLANATION OF PLATES.

PLATE 25.—Lonar Lake from South.
,, 26.—Temple at Lonar.
,, 27.—Panoramic view of Lonar Lake, from N. edge of rim.
,, 28.—Plan of Lonar Lake.

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[1] *Loc. cit.*, p. 137.
[2] Ind. Met. Dept., 1906.
[3] Radium & Geology, p. 242, (1909).
[4] *Chem. News*, 83, p. 265, (1901).
[5] *Jour. Geol.*, 18, p. 190, (1910).
[6] *Rec. Geol. Surv. Ind.*, 38, p. 154 *et seq.*, (1909).

REPORT ON THE ELEVENTH INTERNATIONAL GEOLOGICAL CONGRESS, HELD IN STOCKHOLM IN AUGUST 1910.

BY L. LEIGH FERMOR, A.R.S.M., D.SC., F.G.S., *Superintendent, Geological Survey of India* (With Plate 29.)

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I.—GENERAL.

Meetings, excursions, entertainments.

THE Eleventh International Geological Congress was held in Stockholm, the beautiful capital of Sweden, from the 18th to the 25th of August, 1910.[1] Being at the time on leave in England, I was deputed to attend this Congress as the representative of the Geological Survey of India. It was attended by some 700 geologists from all parts of the world, the special characteristics of Swedish geology attracting a large number of students of glaciation at one end of the geological scale and of Archæan geology and the science of ore-deposits at the other. The session of the Congress at Stockholm was preceded by excursions of one to three weeks' duration to Spitzbergen,[1] Lapland, and Northern Sweden, and followed by others, lasting one to two weeks, to Central and Southern Sweden, with short half-day and whole-day excursions during the session itself to points of interest in the Stockholm Archipelago, and to the island of Visby or Gothland.

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[1] The following reports of previous Congresses have been published by the Geological Survey of India:—2nd Congress at Bologna, 1881, by W. T. Blanford, *Rec. G. S. I.*, XV, pp. 64-76; 3rd Congress at Berlin, 1885, by W. T. Blanford, *Rec. G. S. I.*, XIX, pp. 13-22; 8th Congress at Paris, by W. T. Blanford, *Mem. G. S. I.*, XXX, pp. 225-230; 9th Congress at Vienna, 1903, by T. D. LaTouche, a foolscap report, 10 pp. Blanford also attended the 4th Congress in London, 1888.

The session at Stockholm opened informally on the 17th of August with a *Rèunion* at the Grand Hôtel Royal, in response to the invitation of the Geological Society of Stockholm, the congressists being welcomed by Prof. A. G. Högbom, the President of the Society. On the following afternoon, at a crowded meeting in the Conservatoire de Musique, His Highness the Crown Prince Gustavus Adolphus of Sweden, Honorary President of the Eleventh Session of the Congress, after an eloquent speech in fluent English, asked his father, the King of Sweden, formally to declare the Congress open. His Majesty responded in French, the official language of the Congress.

Messrs. Aguilera and Ordonez, President and General Secretary respectively of the Tenth Session of the Congress in Mexico, thereupon resigned their offices, which were assumed by Messrs. G. de Geer (Professor of Geology, Stockholm University), and J. G. Andersson (Director of the Geological Survey of Sweden), the incoming President and Secretary respectively of the Eleventh Congress.

Professor de Geer, then delivered an address entitled 'A Geochronology of the last 12,000 years,' in which he described his method of determining the length of post-glacial time in the Stockholm area, the chief items of evidence being the seasonally banded clays, and the annual terminal moraines. He deduced that the site of Stockholm was covered by ice only a few thousand years ago, and that Ragunda was covered by ice only 7,000 years ago.[2] The research upon which this address was based was considered by many to be the most important and interesting piece of work brought to the notice of the Congress. It was followed by an address from President C. R. van Hise on 'The influence of Applied

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[1] For an account of the excursion to Spitzbergen, see G. W. Lamplugh, *Nature*, Dec. 1, 1910, pp. 150-157.

[2] *Nature*, p. 440, (1910).

Geology and the Mining Industry upon the Economic Development of the World,' in which particular attention was directed to the vastness of the Swedish reserves of iron-ores, forests, and waterpower, and to the important part Sweden must thereby play one day in the world's industries.

Later in the afternoon, the congressists were received at the Royal Palace (Kongl. Slottet) by Their Majesties the King and Queen of Sweden, inclement weather converting an intended garden party into an indoor function.

The 19th was devoted partly to excursions and partly to sectional meetings, whilst the 20th, 22nd, 24th and 25th were given up largely to the reading of papers. On the 21st the Congress divided into two large excursions: one party visited the Archæan rocks of the island of Utö near Nynäs under the leadership of P. J. Holmquist and Hj. Sjögren, one of the chief attractions being the lithia-pegmatites of Nyköping; we were entertained at dinner in the evening by Prof. and Mrs. Hj. Sjögren at their country house at Nynäs: the other party studied the Quaternary deposits of Upsala, and were entertained in the evening at a Reception given by the University of Upsala. The 23rd, devoted entirely to excursions, was spent by some at Visby, the attractions being the fossiliferous Silurian rocks and the fortifications and other relics of the middle ages, when Visby was a member of the Hanseatic League; others made steamer excursions in the Stockholm Archipelago, visiting the felspar mine of Ytterby, with its rare earth minerals, and the sea-side resort of Saltsjöbaden, whilst another party visited the island of Utö. These excursions afforded excellent opportunities for studying the pronounced glaciation of the islands of the Archipelago. On the 24th, in the evening, the Congress was entertained to a soirée in the gardens of Skansen, which combine the functions of a zoological garden with that of preserving the peasant architecture and customs of the country. At this entertainment, which included Swedish national dances, the festive side of the Congress was closed with speeches by Prof. A. Heim in German, Prof. P. Termier in French, and Dr. Teall in English, thanking the Swedes for their splendid and successful management of the Congress and the excursions, and for their abounding hospitality.

The Congress was formally closed on the 25th of August at a meeting held in the Conservatoire de Musique; the business included the presentation of reports by the various committees already established, as follows :—

(1) International Committee for glaciers.
(2) Committee for the geological map of Europe.
(3) Committee for the Palæontologia Universalis.
(4) Committee for the creation of an International Review of Geology, Palæontology and Petrography.
(5) Committee for the Spendiaroff Prize.
(6) Committee for the Geothermic Degree.

and the consideration of the following propositions :—

(1) A proposal for a standard geological map of the world on the scale of 1 : 1,000,000 ; put forward by Dr. G. O. Smith on behalf of the United States Geological Survey.
(2) A proposition for international co-operation in the study of fractures in the earth's crust; by Prof. W. H. Hobbs.
(3) The establishment of an international geological institute for the exchange of geological objects ; by Mr. E. Stolley.
(4) The preparation of an international dictionary of stratigraphy ; by Mr. L. Waagen.

Finally, there were for consideration invitations from Canada and Belgium with reference to the next Congress. In view both of the fact that the Congress had previously been invited to visit Canada at the time it was decided to accept the Mexican invitation and of the wish of the majority of members, the Belgian invitation was withdrawn, and it was decided to accept the Canadian invitation, conveyed through Prof. F. D. Adams, that the Twelfth Session of the Congress be held in Canada in 1913.

The office of the Congress was situated in the Parliament House (Rigsdags-huset) and the sectional meetings were held in the first and second chambers of the Rigsdag, in the Stockholm University (Högskola) and in the Steel Trust office (Jernkontoret). For the reading of papers, the Congress was divided into the following sections :—

(1) General and Regional Geology. Tectonics.
(2) Petrography and Mineralogy.
(3) Stratigraphy and Palæontology.
(4) Quaternary phenomena. Living glaciers.
(5) Applied Geology.

It is unnecessary to reproduce here the list of papers, which will be found in full in the Report of the Congress, but one paper may be specially mentioned, as it aroused considerable interest. It was Prof. F. D. Adams' paper, entitled 'An Experimental Investigation into the Flow of Rocks,' read before section 2.

In addition to sectional meetings, special meetings were held to discuss the following specific problems :—

(1) Glacial erosion.
(2) The sudden appearance of the Cambrian fauna.
(3) The geology of the pre-Cambrian systems.
(4) The iron-ore supplies of the world.
(5) Should the changes of climate since the maximum of the last period of glaciation be attributed to local or general causes ?
(6) In addition, a general meeting was set aside for the geology of the polar regions.

At each of these special meetings or *discussions*, papers were read by leading exponents of the respective subjects, the number of papers offered being usually too large to allow of any real discussion. In fact the only criticism that can be levelled at this admirably arranged Congress is with regard to these discussions. For the adequate consideration of a given question, some carefully selected authority should introduce the subject and specify the points before the meeting; the succeeding speakers should then discuss these given points, instead of reading rival papers often dealing with somewhat distant branches of the subject.

Glacial questions.

The discussion on *glacial erosion* consisted of papers by W. M. Davis, H. G. Högbom, A. Penck, H. Reusch, and O. Nordenskjöld, with many contributed remarks. That on *climatic changes since glacial times* was introduced by Mr. G. Andersson; in connection with this subject the 11th Congress has issued a work entitled 'Die Veränderungen des Klimas seit dem Maximum der Letzten Eiszeit,' consisting of reports in English, French, and German, by leading geologists in most lands where the glacial period has left traces.[1] At the meeting devoted fo the *geology of the polar regions*, papers were read by A. G. Nathorst, F. J. Pompeckj, N. V. Ussing, O. Nordenskjöld,

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[1] Published by Generalstabens Litografiska Anstalt, Stockholm, 1910, p. 459.

E. David and R. Priestley, and E. Gourdon. In this connection mention may be made of a special collection of polar specimens (illustrating particularly the geology of Spitzbergen) arranged for the Congress at the offices of the Swedish Geological Survey.

Sudden appearance of the Cambrian fauna.

The subject of the *sudden appearance of the Cambrian fauna* is of great interest to students of Indian Geology, particularly of the Purana formations. Consequently, the list of papers comprising this discussion is given below:—

O. Jaekel: Die Entstehung des organischen Lebens auf der Erde.
W. J. Sollas: The Fauna of the Protæon.
R. A. Daly: Some Chemical Conditions in the Pre-Cambrian Ocean.
J. Walther: Die lithologischen Eigenschaften des Liegenden des Kambriums.
J. J. Sederholm: Sur les vestiges de la vie dans les formations progonozoïques.
Ch. Barrois: Sur l'origine du graphite dans les systèmes précambriens.
A. Rothpletz: Enthalten die Kalkgerölle des unteren Sparagmits Vorlaüfer der kambrischen Flora und Fauna?
G. Steinmann: Die kambrische Fauna im Rahmen der organischen Gesammtentwicklung.
J. W. Evans: The Sudden Appearance of the Cambrian Fauna.
C. D. Walcott: The Abrupt Appearance of the Cambrian Fauna on the North American Continent.
G. F. Matthew: The Cambrian Fauna of eastern Canada and southern Newfoundland.

Classification of the pre-Cambrian.

The discussion on the *geology of the pre-Cambrian systems* is also of great interest to geologists working in India, where about two-thirds of the Peninsula is occupied by rocks of such age. The following is the list of papers read:—

F. D. Adams: The Origin of the deep-seated Metamorphism of the pre-Cambrian Crystalline Schists.
J. J. Sederholm: Die regionale Umschmelzung (Anatexis), erläutert an typischen Beispielen.
P. Termier: La genèse des terrains cristallophylliens.

Ch. Barrois: Le metamorphisme de profondeur en Bretagne.

Joh. Koenigsberger: Über die krystallinen Schiefer der centralschweizerischen Massive verglichen mit denen anderer Länder.

A. P. Coleman: Metamorphism in the Pre-Cambrian of Northern Ontario.

F. Becke: Über das Grundgebirge im niederoesterreichischen Waldviertel.

U. Grubenmann: Einige tiefe Gneisse aus den Schweizer-Alpen.

A. C. Lane: The Stratigraphic Value of the Laurentian.

W. G. Miller: The Principles of Classification of the Pre-Cambrian rocks, and the extent to which it is possible to establish a chronological classification.

J. J. Sederholm: Subdivision of the Pre-Cambrian of Fenno-Scandia.

J. F. Kemp: Archean rocks of the Adirondack area.

A. P. Coleman: Methods of Classification of the Archean of Ontario.

Judging from the papers and such discussions as took place thereon, it became evident that the division of the North American pre-Cambrian into Algonkian and Archæan, with the limits advocated by Van Hise, was not acceptable to many, even of the American and Canadian geologists, a more natural classification being one that grouped together, as one main (lower) division, the Keewatin, Laurentian, and Huronian Proper (lower or middle Huronian), referring the Animikie (upper Huronian) and the Keweenawan to one main (upper) division; the chief objection to Van Hise's nomenclature is that he includes the Huronian in the Algonkian, thus grouping together the highly metamorphosed schists of this formation and the, comparatively-speaking, unmetamorphosed Animikies and Keweenawans; whilst the Laurentian granites referred by Van Hise to his lower (Archæan) division are intrusive into at least a portion of the Huronian. This difference of classification is summarised in the accompanying table, columns I to III.

TABLE I.—*General classification of the Pre-Cambrian Formations of Laurentia, India, S. Africa, Scotland, and Fennoscandia.*

I Division of the pre-Cambrian as advocated by Van Hise and Leith.[1]	II North America (Laurentia).	III More natural classification.[2]	IV India.	V South Africa.[3]	VI Scotland.[4]	VII Sweden.[5]	VIII Finland.[6]
Algonkian .	Keweenawan	**Purana**	Vindhyans	Witwatersrand System.	Torridonian	Seve-group (Sparagmites) Dala sandstone Dalsland series	Jotnian. Jatulian.
	Animikie (Upper Huronian).		Cuddapahs				
	GREAT EPARCHÆAN INTERVAL.						
	Huronian .	**Archaean**	Dharwarian Khondalites Schistose gneisses and oldest gneisses.	Swaziland Series.	Lewisian.	I. Granite-porphyry leptite group =Kalevian to Ladogian.	Kalevian. Bothnian.
Archæan .	Keewatin .						
	Eruptive unconformity. Laurentian .		*Eruptive unconformity.* Eruptive gneisses and granites: charnockites and anorthosites.	*Eruptive unconformity.* Eruptive gneisses and granites.		II. Gneiss-group =pre-Bothnian to Katarchæan.	Ladogian. Katarchæan.

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[1] Pre-Cambrian Geology of North America, *U. S. Geol. Surv.*, Bull. 360, (1909), p. 42.

[2] T. H. Holland: Presidential Address, *Trans. Min. Geol. Inst. Ind.*, I, pp. 47-49, (1906); Imperial Gazetteer of India, I, pp. 54, 55, (1907).

[3] Report of the Committee on South African Strata, *Brit. Ass. Reports*, 1910, p. 130.

[4] Geological Structure of the North-West Highlands of Scotland, *Mem. Geol. Surv. Great Britain*, (1907).

[5] A. E. Törnebohm, Geological Map of Sweden, 2nd Edition, 1910, scale 1: 1,500,000; J. J. Sederholm, Les roches préquaternaires de la Fennoscandia, Helsingfors, (1910).

[6] J. J. Sederholm, Om granit och gneis, *Fennia*, XXVI, No. 2, p. 93, (1907).

In the absence of Sir Thomas Holland, who was prevented at the last moment from attending the Congress, I joined in this discussion and explained the similarity of Sir Thomas Holland's division of the Indian pre-Cambrian rocks into Purana and Archæan with the more natural division of the North-American pre-Cambrian referred to above (see column 3 of the table); and, consequently, that it would be possible to extend the application of the term *Purana* beyond the limits of India and apply it to the upper division (Keweenawan and Animikie) of the American pre-Cambrians, whilst grouping together under the term Archæan all the systems below the Animikie, and thus obviating the use of the much-abused term Algonkian and applying the term Archæan in a sense more in conformity with Dana's original definition. I have since seen the report of the British Association Committee appointed to investigate and report on the correlation and age of the South African strata and on the question of a uniform stratigraphical nomenclature (*British Association Report* for 1910, pp. 123-142), and observe that Prof. Gregory, the Chairman, advocates the extension of this two-fold division of the pre-Cambrian to South Africa. Sir Thomas Holland's remarks in this report (pp. 133-138) deserve particular attention.

In table 1, I have attempted a rough classification of the pre-Cambrian formations of North America, the Peninsula of India, South Africa, Scotland, and Fennoscandia, into these two main divisions—Purana and Archæan—, laying stress on the essential difference between the comparatively unmetamorphosed character of the formations lying above the Eparchæan Interval and the highly metamorphosed character of those formations lying below this great break. No stress is laid upon the equivalence of subdivisions of the Puranas or Archæans of one country with those of another, although in certain cases the correlation of formations placed on the same level bears a certain *primâ facie* probability, *e.g.*, the Huronian with the Dharwarian, and the Laurentian with the Indian eruptive gneisses and granites. This method of subdividing the pre-Cambrian on the basis of the degree of metamorphism and disturbance of its constituent formations can be applied in the first instance only to such ancient undisturbed portions of the earth's surface as the Laurentian Shield of North America, the Peninsula of India, South Africa, and Brazil. In Fennoscandia and Scotland, for example, the differences between the Puranas and Archæans have been to some extent obscured by the Caledonian overthrust movements, with the result that one facies of the Seve group (Seve schists) of Sweden is extremely schistose and crystalline, and might at first sight be regarded as Archæan, until its equivalence to the unmetamorphosed facies of this group was recognised. Similarly, in the north-western Highlands of Scotland, the series of schists known as the Eastern Schists would at first sight be regarded as Archæan; but this series is now known to comprise metamorphosed portions not only of the Lewisian, but also of the Torridonian, and of the Cambrian formations. In regions affected by the Tertiary mountain-building movements, for example in the Himalayas, rocks of all ages up to Tertiary may be found converted into crystalline schists, and the interpretation of their age and position in the geological scale then depends on careful stratigraphical work. Nevertheless, we believe we can recognise in the Himalayas representatives of both Purana and Archæan formations of the Peninsula: thus the Dalings of Sikkim may correspond to the Dharwars (Archæan) and the dolomitic limestones of Kumaon to one of the Purana formations.

Dr. Sederholm in explaining the classification he had adopted for Fennoscandia, proposed to call all the pre-Cambrian rocks the *Progonozoic*, and to divide them into three divisions with the prefixes *Archeo*, *Meso*, and *Næo*.[1]

World's iron-ore supplies.

The subject of the *iron-ore supplies of the world* concerns directly or indirectly every civilised being and every civilised country, but more particularly those countries which are fortunate enough to be the possessors of considerable supplies of iron-ores and are therefore either enjoying present industrial prosperity, or are entitled to expect it in the future when the iron-ores are mined and made available to mankind. Sometime previous to the Eleventh Congress, the Committee of the Congress issued a circular to the Geological Surveys, or Mining Bureaus, of all countries that were likely to be able to respond; as a result they were able to issue, some months before the Congress met, a most valuable work, entitled 'The Iron-ore Resources of the World,'[2] in two volumes, with an atlas volume. This work contains reports in English, French, or German, on the iron-ore supplies of all countries concerning the iron-ore resources of which there is any available information, written by well-chosen authorities in each country. Numerical estimates of the quantities available are given wherever possible. These estimates are summarised by Prof. Hj. Sjögren in an introductory section, from which one gleans that the world's iron-ore reserves are as follows :—

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[1] The paper 'Les roches prequaternaires de la Fennoscandia' with geological map, specially written for the Congress by Dr. J. J. Sederholm, and presented to the Congress by the Geological Survey and Geographical Society of Finland, is worth careful study by all students of pre-Cambrian Geology.

[2] Published by Generalstabens Litografiska Anstalt, Stockholm.

World's summary.

	ACTUAL RESERVES.		POTENTIAL RESERVES.	
	Ore. MT.*	Iron. MT.	Ore. MT.	Iron. MT.
Europe . .	12,032	4,733	41,029	12,085+considerable.
America .	9,855	5,154	81,822	40,731 +enormous.
Australia . .	136	74	69	37+considerable.
Asia . .	260	156	457	283+enormous.
Africa . .	125	75	many thousands.	many thousands +enormous.
TOTALS .	22,408	10,192	>123,377	>53,136+enormous.

* MT=million tons.

At the present annual rate of production of pig-iron, the actual world's reserves of iron-ore would be consumed in less than 200 years; but on the assumption that the world's consumption will go on increasing at the present rate of increase, the actual reserves are sufficient only for 60 years' supply. It is noticeable, however, that as our information concerning a given portion of the earth's surface increases, so does the available known supply of iron-ore; and by dividing the actual and potential resources of the best-known portion of the earth's surface, *viz.*, Europe, United States of America, and Japan, by the area expressed in square kilometres, Prof. Sjögren obtains a quotient (404 for the actual and 2,838 for the potential reserves, or together 3,242, expressed as metallic iron) which he calls the *iron quotient* for the area in question. This, he thinks, may be applied roughly to the whole of the earth's surface (nearly 131,000,000 sq. km.), and on this basis he deduces the existence of 424,487MT actual and potential reserves of iron. Prof. Sjögren also points out the extent to which the future production of iron will become dependent upon the use of low-grade ores, and upon the progress of technical knowledge by which iron-ores, at present valueless, might be utilised; he indicates in a table the chief known and recorded ore-deposits with ore of 60 per cent. Fe. and above, from which one gleans that of these comparatively small reserves of high-grade ores India possesses the next largest store to Sweden.

The discussion on this subject took place in the Riddar-huset (Knight's House), the walls of which are decorated by some thousands of miniature shields with the coats-of-arms of the nobility of Sweden, a fit setting for a discussion on the future supplies of the metal that forms the chief sinews both of war and of industry. Special seats were reserved for all the co-authors of the volumes referred to above who were present. The subject was introduced by Mr. A. Lindman, the Swedish Prime Minister, who outlined the policy followed by the Swedish Government in granting mining claims, and in limiting the exports of iron-ore.[1] This address was followed by a statistical exposition by Prof. Sjögren, and by communications from Messrs. Ramon Adam de Yarza, L. de Launay, F. Beyschlag, J. F. Kemp and H. Louis. This discussion revealed a general agreement on one main point, *viz.*, that in view both of the known resources of iron-ores of the better-studied countries and of the vast but unmeasured reserves of ore reported from many of the wilder and geologically less-known countries, there is no ground for uneasiness concerning the world's supplies of iron-ore for many years to come, but, rather that we should be uneasy concerning the rapid consumption of coking coals. Whilst referring to this international work on the world's iron-ore resources, it is interesting to note that the Canadians have resolved to follow it up with an international volume on the *world's coal resources* for the next Congress.

In closing this section of the report, one must refer with admiration to the excellent arrangements made by our Swedish colleagues both for the meetings at Stockholm and for the excursions, one of the most praiseworthy features being the excellent series of Guides to the excursions, all specially written for the occasion and many of them rendering available to all geologists interesting researches that have hitherto been inaccessible to many on account of their publication in Swedish. Finally, one must admire and envy the general education of a country in which the advent of an International Congress arouses interest throughout the length and breadth of the land from the lowest to the highest and makes it worth the while of the newspapers to report the Congress doings in many columns day by day.

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[1] See *Iron and Coal Trades Review*, 2nd Sept. 1910, p. 361.

Second Agrogeological Congress.

As an experiment the Second International Agrogeological Congress was held in Stockholm simultaneously with the Geological Congress. But it has been recognised that the relations between the two congresses are not close enough to render it desirable that they should be held at the same place and time, and the next Agrogeological Congress has been fixed for 1914 in St. Petersburg. The present Congress was under the Presidentship of Prof. Gunnar Andersson, but except in his presidential address little attention was devoted to the geological aspects of soils, most of the papers relating more to physics, chemistry, and plant physiology.[1]

II.—THE IRON-ORE DEPOSITS OF LAPLAND.

Historical.

One of the most attractive excursions of the Congress was the visit to the principal iron-ore deposits of Lapland, *viz.*, Gellivare, Kiirunavaara, Luossavaara, and Tuolluvaara all situated within the Arctic Circle, the latitude of Kiruna, the centre for the last three deposits, being 67° 50′ north, and that of Gellivare 67° 11′ north. The iron-ore deposits of Gellivare and Kiruna have been known since early in the eighteenth century, and a certain amount of mining and local smelting has taken place at intervals; but it was not until the introduction of the basic Bessemer process and the building of the Lapland railway, the most northern in the world, that these iron deposits became of real economic importance. The first ore was despatched by rail from Gellivare in 1887, but the railway did not reach Kiruna until 1899. Since that date, there has been a great development in the export of ore from the Lapland ore-fields; the total for the year 1909 is 956,000 tons from the Gellivare ore-fields, 1,592,000 tons from Kiirunavaara, and 70,000 tons from Tuolluvaara, Luossavaara not having yet been opened up to any extent; the total quantity exported since the year 1892 is over 25,000,000 tons, of which 15,000,000 tons have been shipped from the port of Luleå on the Baltic, and nearly 10,000,000 tons from the Norwegian port of Narvik on the Ofoten Fjord. Of these quantities, some 74 per cent. goes to Germany, 17 per cent. to England, and 7 per cent. to Belgium and France. Kiirunavaara is the largest single known deposit of iron-ore in the world, and has been estimated to contain 240,000,000 tons of iron-ore above the surface of Luossajärvi, a small lake lying between it and Luossavaara, and about 500,000,000 tons below the level of this lake, the existence of ore to a depth of 300 metres below this lake having been proved by boring. Gellivare Malmberg (ore-mountain) is estimated to contain 270,000,000 tons of ore and certain other Lapland deposits enough to bring the grand total up to 1,158,000,000 tons of ore. There are many other known deposits of iron-ore in Lapland, but they have not yet been sufficiently exploited for any estimates of quantities to be made; and there is little doubt that systematic exploitation of this country with the magnetometer will lead to the discovery of other deposits at present hidden beneath the peat mosses that fill all the hollows of this part of Northern Sweden. There is, therefore, no doubt that Lapland is destined to play an extremely important part in the supply of ore to the furnaces of Europe and probably also of North America for many years to come, and, under these circumstances, a brief account of the geology of these remarkable deposits should be of great interest to people in India.

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[1] See *Nature*, Nov. 17, 1910, p. 88, for a short report.

According to an agreement made in 1907, the Luossavaara Kiirunavaara Aktiebolag (L. K. A. for short: *Aktiebolag*=share company or limited company) took over the mines in the Gellivare iron mountain, and handed over half of its share capital to the Swedish State, which undertook to transport 93,250,000 tons of ore from Kiirunavaara (75,000,000 tons) and Gellivare (18,250,000) to the harbours at Narvik and Luleå at a certain fixed rate of freight, the Swedish State receiving the option to acquire by purchase, after 25 years and on certain fixed conditions, the other half of the shares in the ore-field company. At the same time the total production from these mines was limited to the total to be transported during the said 25 years, the permissible annual maximum production from 1913 onwards being 3,175,000 tons from the Kiirunavaara area, and 687.500 tons from the Gellivare area. The L. K. A. is controlled by the Trafikaktiebolaget Grängesberg-Oxelösund, which owns the half of the share capital not belonging to the Swedish State, and also possesses the Grängesberg iron mines of Central Sweden. According to the same agreement the export from the

Grängesberg field in Central Sweden is not to exceed an annual amount of 650,000 tons during the period 1908-1917, nor after 1917, an annual amount of 450,000 tons. In addition to this giant corporation, there are two smaller companies, one working the Tuolluvaara mine, and the other, an Austrian company, working a portion of the Gellivare iron mountain known as Koskullskulle.

For accounts of the geology of the iron-ore deposits of Swedish Lapland, reference to the following publications is advised:

(1) Guides Nos. 4 and 5, published by the Geological Congress, *viz.*, 'The Gellivare Iron Mountain' by A. G. Högbom, and 'Sketch of the Geology of the Kiruna District' by Hj. Lundbohm;

(2) Dr. O. Stutzer's paper entitled, 'The Geology and Origin of the Lapland Iron Ores,' *Journal of the Iron and Steel Institute*, No. II, 1907, pp. 106-206;

(3) The account, by Hj. Lundbohm and W. Petersson, of the iron-ore resources of Northern Sweden, given in the 'Iron-Ore Resources of the World,' Vol. II, pp. 553-585, published by the International Geological Congress; and lastly,

(4) 'The Geology of the Kiruna District, No. II, Igneous Rocks and Iron-ores of Kiirunavaara, Luossavaara and Tuolluvaara,' by Dr. Per Geijer, published by P. A. Norstedt & Söner, Stockholm, for the Luossavaara Kiirunavaara Aktiebolag.

Besides arranging for, and paying, all the costs of Dr. Geijer's research, this generous and enterprising company has also published Memoirs on the Magnetic Survey of Kiruna by V. Carlheim Gyllensköld; and on the glacial geology of the same area, by O. Sjögren. It was noticed by Dr. Lundbohm that the construction of the railway into Lapland, and the building of the town of Kiruna was causing a great change in the flora of that neighbourhood, and he consequently arranged for a botanist, Mr. Herman G. Simmons, to make a thorough study of the flora of the Kiruna district, with the resultant production of an elaborate memoir, entitled 'Floran och Vegetationen i Kiruna,' in which the Kiruna area is divided up into a large number of botanical districts and the flora of each analysed into its indigenous and exotic plants, this work being also published by the L. K. A.

I propose first to deal with the Kiruna area. The systematic study of this region was first undertaken by Hjalmar Lundbohm of the Swedish Geological Survey, and now the General Manager of the L.K.A. Geological maps of the Kiirunavaara district are to be found in Lundbohm's Guide mentioned above and also in Dr. Geijer's memoir. Briefly stated, the geology is as follows:—

Kiirunavaara and Luossavaara.

The Kiirunavaara and Luossavaara deposits are aligned on a general north and south line, Luossavaara lying to the north of Kiirunavaara with the lake known as Luossajärvi lying between. Each of these deposits gives rise to a hill, Kiirunavaara rising 248 metres above the lake. The Kiirunavaara deposit is a little over 5 kilometres long, and the Luossavaara deposit 1·2 kilometres long. In Kiirunavaara, the ore dips to the east at about 54°, the average thickness of the deposit at right angles to the hanging and foot-walls being 78 metres, with a maximum thickness of 164 metres on the hill known as Geologen. The ore has been proved by diamond-drill borings to continue to a depth of 300 metres below the lake. The foot-wall of the ore deposit is a *syenite-porphyry* passing down into syenite, whilst the hanging wall is a more acid porphyry termed *quartz-porphyry* by Geijer, although there are, as a rule, no visible quartz phenocrysts. Both porphyries are characterised by high percentages of soda as compared with potash, whilst they frequently contain a not inconsiderable amount of magnetite. Titanium is invariably present, and usually takes the form of sphene. In addition to the main masses of the porphyries, there are also dykes both of quartz-porphyry and of syenite-porphyry, the latter cutting into the ore-body. To the north of Luossavaara, there is a zone of the foot-wall porphyry very rich in magnetite, an analysis given by Geijer showing 63·8 per cent. of albite and 28·7 per cent. of magnetite. This rock is regarded by Geijer as only a schlieric phase of the syenite-porphyries, with the normal form of which it is connected by all intermediate gradations. There are in several places, in both the foot-wall and hanging-wall porphyries to the north and east of Luossavaara, very numerous small veins of apatite, usually but a few centimetres wide, but ranging, in one case, between the widths of 0·5 to 2 metres for a length of 40 metres, the dyke itself containing fragments of the quartz-porphyry into which it is intruded; these dykes contain also magnetite and hematite, and, less frequently, tourmalines. On the foot-wall side of the Luossavaara deposit, there are very numerous veinlets of magnetite extending from the ore-deposit into the foot-wall syenite-porphyry. The ore-body itself includes in places fragments of this foot-wall porphyry, whilst on its hanging wall fragments of the ore-body itself are seen to be included in the hanging-wall porphyry. The ore-bodies themselves consist almost entirely of two minerals, magnetite and apatite, the magnetite being, as a rule, predominant; but there is every gradation from practically pure magnetite-rock to practically pure apatite-rock, the patches rich in apatite occurring as schlieren in the parts rich in magnetite. The structures of the various associations of magnetite and apatite found in the ore-body are taken to indicate that these two minerals have solidified together from a molten magma.

Based on the abundant evidence collected at both Kiirunavaara and Luossavaara, of which some of the important points only have been mentioned above, both Stutzer and Geijer are in full agreement with the opinion originally propounded by Högbom that the whole complex is the result of magmatic differentiation from a syenitic mother magma; and I think that almost every one who has visited these deposits and studied the evidence available in the field and read also the accounts of these deposits published by Stutzer and Geijer, and particularly the microscopic descriptions and chemical analyses given by the latter, is in full agreement with the magmatic theory. The chief difference between Stutzer's and Geijer's theories as to the mode of formation of these deposits lies in the actual mode of eruption of the three chief members of this igneous complex, the foot-wall syenite-porphyry, the apatite-magnetite ore-body, and the hanging-wall quartz-porphyry. From the evidence detailed roughly above it will be seen that although there was probably not much difference in time between the eruption of these three units, yet the evidence points to the foot-wall porphyry being the oldest and the hanging-wall porphyry the youngest of the three members. With this both Geijer and Stutzer agree: but Stutzer maintains that the magnetite ore-body and its associated rocks are of the nature of magmatic intrusions, or magmatic veins, intruded into the rocks overlying and underlying this igneous complex; whilst Geijer maintains that they are a series of surface lava-flows, the syenite-porphyry having been erupted on to the surface of the underlying Kurravaara complex, followed by the apatite-magnetite rocks as another surface lava-flow, and this in turn by the quartz-porphyries as the final volcanic extrusion; and then, according to Geijer, the overlying Hauki schists and quartzites were deposited on the top of the quartz-porphyry. Stutzer maintains that these overlying Hauki schists can be divided into two series, one of which is older than the igneous rocks, which are intrusive into it, whilst the other is younger and contains pebbles of the igneous rocks. Stutzer, then, regards this igneous series as having been intruded between the Kurravaara complex on the foot-wall side and the lower division of the Hauki schists on the hanging-wall side. In my opinion, the distribution of the rocks, as shown on the map (which is explained by Geijer as due to faulting), taken in conjunction with the downward passage of the syenite-porphyry into syenite, and various other features of the rocks, indicate that Stutzer is nearer the truth when he maintains an intrusive origin for these rocks than is Geijer in maintaining an extrusive volcanic origin.

Many other theories have been previously propounded to explain the origin of these deposits, but most of them pre-date the large mass of facts that are now available, and the only other theory which seems now worth considering in the light of present evidence is the theory that these deposits are of pneumatolytic origin, as has been previously maintained by Bäckstrom and De Launay. This alternative has been fully discussed by Geijer and cannot, I think, now be maintained; but I agree with Geijer in thinking that the available evidence indicates that although the ore-bodies have solidified direct from the molten condition, their solidification was accompanied by a certain amount of pneumatolytic action.[1]

Gellivare.

The *Gellivare deposits* differ considerably from those of Kiruna, not in chemical composition, but in their structural peculiarities, and a study of the available evidence seems to indicate that the Gellivare ore-bodies in a country of syenitic gneisses represent merely a very much metamorphosed Kiruna.

Assuming the correctness of the theory that these apatite-magnetite ore-bodies have been formed by magmatic differentiation from a syenitic magma very rich in soda and also comparatively rich in iron, it is interesting to note the importance of this type to the petrologist. Hitherto, the majority of ore-bodies whose origin was ascribed to magmatic differentiation have been found in association with basic igneous rocks, such as gabbros, anorthosites, and serpentine, the ore-minerals found in such associations being titaniferous magnetites, chromite, and certain nickeliferous pyrrhotites. It is interesting then to note that such basic masses as iron-ore deposits can also be formed by magmatic differentiation from comparatively acid rocks such as syenites. Geijer compares the Lapland magnetite bodies with a group of magnetite deposits (Blagodat, etc.), found in the Northern Ural, where the magnetite is associated with syenitic rocks, both syenite and porphyry, magnetite-syenite phases also occurring; Tschernyschew and Högbom regard there ore-bodies as schlieren in the syenitic rocks. Geijer advances his reasons for supposing that the magnetite ore-bodies associated with the syenitic rocks are the final products of differentiation, the mineralising agents collecting into the portions of the magma rich in iron, the apatite and ore-bodies being equivalent, therefore, to the pegmatites from an ordinary granite. For this reason he adopts the term *pegmatite type* of Leith, indicating that the iron-ore bodies associated with the syenitic rocks are the residual products from the separation of syenitic rocks from the mother magma, and are thus related to the syenites in an exactly opposite way to the relation that holds between ore-bodies associated with the basic rocks such as gabbros.

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[1] Mr. W. H. Heidsman has recently read before the Iron and Steel Institute a paper entitled 'On the Organic Origin of the Sedimentary Ores of Iron and of their Metamorphosed Forms. The Phosphoric Magnetites' taking as his chief example Kiirunavaara. See *Iron and Coal Trades Review,* May 12th, 1911.

During the excursion to Kiirunavaara, we all collected on the top of the highest peak, known as Statsrådet, where we were addressed by Dr. Lundbohm on behalf of the L. K. A. He explained that this was the original mountain top, which he had kept carefully preserved for the visit of the International Geological Congress, and that it was then, as we stood upon it, drilled and charged with 20,000 lbs. of dynamite, this information arousing momentary looks of alarm on the faces of the many geologists present. Dr. Lundbohm further informed us that he proposed that evening to blow into the air this portion of the kingdom of Sweden. After the banquet, hospitably offered to us by the L. K. A. in the Kiruna school room adorned with the dwarf birch so characteristic of Lapland, we adjourned to the verandah of Dr. Lundbohm's house. At the request of Dr. Lundbohm, President

Van Hise, as one of the leading authorities on the geology of iron deposits, pressed a button and sent an electric message to the top of Kiirunavaara. The result was not as impressive as we had anticipated, even as seen from the distance of nearly 2 kilometers, but we were informed the next morning that about 20,000 tons of iron-ore had been blasted out.

The quality and classification of the ores exported from Kiruna is shown by the following table:—

TABLE 2.—*Analyses of Kiruna Ores.*

Quality.	Period.	Tonnage.	AVERAGE CONTENTS.	
			Iron.	Phosphorus.
A . . .	1903—09 .	1,141,302	69·63	0·024
B . . .	1905—07 .	67,387	69·25	0·067
C . . .	1904—09 .	371,854	68·60	0·162
D . . .	1903—09 .	7,003,158	62·48	1·88
F . . .	1901—05 .	278,966	59·34	2·78
G . . .	1903—09 .	708,636	57·77	3·09

III.—THE ORE-DEPOSITS OF CENTRAL SWEDEN.

In addition to the Laponian iron-ore deposits, I was able, as a member of excursion C. 4, to visit several of the famous mines of Central Sweden under the leadership of Messrs. Hj. Sjögren, W. Petersson and H. E. Johansson, the most recent workers in this province. The mines visited by this excursion were in order:—(1) The Dannemora Iron Mine in the province of Upsala; (2) the Sala Silver Mine in Västmanland; (3) the Norberg Iron Mines, also in Västmanland; (4) the Flogberg Iron-ore Deposit and

Briquetting Plant in Kopparberg; (5) the Falun Copper Mine in Kopparberg; (6) the Grängesberg Iron Mines, also in Kopparberg; (7) the Långban Manganese-Iron Mine in Värmland; (8) the Persberg Iron Mines, also in Värmland; (9) Åmmeberg Zinc Mines in Närke and Östergötland; and (10) the Taberg Titaniferous Magnetite Deposit in Småland. I left the excursion party at Långban in order to devote to this famous mine more time than was permitted by the excursion; for providing me with guidance underground, I have to thank Mr. H. V. Tiberg, the *Disponent* or Engineer of this mine. I then visited the disused Jakobsberg Manganese Mine, being helped in this case by Mr. Dahlgren, the Engineer of the Nordmark Iron Mines.

Historical.

Many of these mines have been in operation for several centuries. Thus the *Falun Copper Mine* was worked at least as far back as the beginning of the thirteenth century by the Stora Kopparbergs Bergslags Aktiebolag. (Literally, the great copper-mountain mining-district share-company), founded about the year 1225, and the oldest stock company in Scandinavia; this company has extended its operations to forests and to iron, owning the Skutskär Saw-mills, Sulphite and Sulphate Pulp Mills, the Domnarfvet Paper Works, and the Domnarfvet Iron and Steel Works, the largest iron works in Scandinavia, and the largest in the world based on charcoal as fuel. From the Falun Copper Works the company obtains gold, silver, bismuth, sulphates of copper, iron, and aluminium, sulphuric acid, and red mineral paint. The total yield of the Falun Mine during nearly 700 years has been about 500,000 tons of copper, 15·5 tons of silver, and 1·2 tons of gold, with a total value of over £55,000,000.

Of the other ancient mines, *Dannemora* was discovered in 1481 and worked as a silver mine, the production of the world-famous Dannemora charcoal-iron, from which Sheffield cutlery has been long manufactured, commencing in the sixteenth century. The *Sala Silver Mine* (argentiferous galena) has been worked since early in the sixteenth century, and is estimated to have yielded 400 tons of silver during four centuries, but it is calculated that this mine has been run at a loss for some three centuries and a half of this period, the work having been rendered possible only by extensive Government privileges. Of late years attention has been directed to the zinc-ores of this mine. The *Norberg Iron Mines* have been worked since the 13th century, and have yielded, up to 1909, 9,000,000 tons of ore. The *Långban Mines* are also very ancient, and there is record of a furnace at Långban as far back as 1550. The Långban Mines have been worked for iron and silver, and it was not until well on to the nineteenth century that the manganese-ores were discovered, and mining now goes on for both the iron-ores and the manganese-ores. The output from Långban is very small, being, in 1908, 6,442 tons of iron-ore and 3,179 tons of manganese-ore. The oldest mining field in Värmland is Nordmark, and next to that Persberg, where mining started in the thirteenth century.

Many of these mines have reached considerable depths, in some cases, for example at Falun, as much as 1,000 feet; and, as one would expect in a region where mining has been operative for such a length of time amongst the old crystalline rocks, a great variety of splendid mineral specimens has been obtained; in fact, Sweden is one of the richest countries for minerals in the whole world. Thus the mineral district comprising Långban, the other less important manganese mines of Värmland, and the Nordmark iron-mines, has yielded at least 120 well-marked mineral species, of which 48 have not been found elsewhere[1]; the Långban-Nordmark district is indeed the richest in the world, the Vesuvius-Monte Somma (Italy) and Langesundfjord (Norway) districts standing second (about 80 species each).

Geological occurrence.

Treated broadly, the geology of Sweden is simple. A very considerable part, almost the whole, of the country is occupied by rocks of Archæan age; but along the Norwego-Swedish frontier there is a considerable area of rocks classed by the Swedish geologists as Algonkian, and resting on these are Palæozoic rocks ranging in age from Cambrian to Silurian. In Southern Sweden and on the island of Gothland, there are other small areas of Palæozoic rocks, whilst in the south-west corner of the country (in Skåne) there are Mesozoic rocks ranging from Cretaceous to Rhaetic. Finally, there are post-Archæan igneous rocks of various ages, and, in many parts of the country, a thick mantle of glacial deposits. All the Swedish ore-deposits are situated in the Archæan rocks, which have been sub-divided by Swedish geologists into many divisions according to their petrographical composition. These are grouped into two main divisions by Swedish geologists, the lower being the gneiss group consisting of gneisses of various compositions, and the upper, the granite-porphyry-leptite group, comprising various porphyries, gneissic rocks, leptites, amphibolite-schists, mica-schists, quartzites, clay-slates, conglomerates, and limestones, with syenites and a great variety of granites, the granites being regarded as the youngest member of this group. *Leptite* is a Swedish term used to describe rocks that earlier were termed hälleflinta-gneiss. They are equivalent to the granulites of other European countries.

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[1] Beyschlag-Krusch-Vogt. Die Lagerstatten der Nutzbaren Mineralien und Gesteine, Vol. I, p. 385, (1910).

Origin.

The Swedish ore-deposits are mainly associated with the leptites or granulites and the crystalline limestones, which are frequently dolomitic. With regard to the mode of occurrence and origin of these Swedish ore-deposits an enormous volume of literature has arisen, in which the most varied views have been advanced to account for the formation both of the ore-deposits and of their associated rocks. The science of ore-deposits itself has been passing through a wonderful transformation in the last few years, especially at the hands of American geologists; and Swedish geologists have been gradually revising their work and opinions and bringing the theoretical side of the question into line with modern ideas. Even at present there is a great want of uniformity and agreement with regard to the origin of these Swedish deposits. Thus, according to the work of Törnebohm, all the Swedish ore-deposits, with their enclosed rocks, are merely metamorphosed sediments, whilst Johansson, following up his work on the Grängesberg iron deposits, is inclined to regard all the Swedish iron deposits as magmatic segregations. In order to illustrate the diversity and uncertainty of opinion with regard to this fascinating question, I have drawn up a table (No. 3) showing the origin ascribed to each of the deposits mentioned in this report according to the following well-known text-books on ore-deposits :—

(1) 'The Nature of Ore-Deposits,' by Beck & Weed, (1905).
(2) 'Die Erzlagerstätten,' by Stelzner & Bergeat, (1904-06).
(3) 'Lehre von den Erzlagerstätten,' by Beck, (1909).
(4) 'Die Lagerstätten der Nutzbaren Mineralien und Gesteine,' Vol. I, (1910), by Beyschlag, Krusch, and Vogt.

From this table it will be seen that the Kiirunavaara iron-ore deposit, now almost universally regarded as of magmatic origin, was, even as recently as 1905-06, classified by Stelzner and Bergeat with the bedded or stratified ore-deposits (*Schichtigen Lagerstätten*), whilst the Grängesberg iron-ore deposits, lately shown by Johansson to be in all probability products of magmatic differentiation, are classified in three of these works as sedimentary deposits, and in one of them as a contact deposit. Three out of these four works classify the Norberg, Persberg, and Dannemora iron-ore deposits with the metamorphosed sediments, though often with doubt. But I think it probable that further research will show that not a single one of the Swedish ore-deposits enumerated in table 3 is the product of the metamorphism of sediments. In the last column I have indicated, as far as possible, the probable genetic positions of these deposits, judging partly from my own visits, and partly from the published accounts. In some cases I have not ventured to express a definite opinion. Since the Congress excursions, Dr. Alfred Bergeat, the co-author of one of the text-books quoted, and a member of excursion C. 4, has published an interesting paper entitled 'Die genetische Deutung der nord-und mittelschwedischen Eisenerzlagerstätten in der Literatur der letzten Jahre,' summarising the recent literature and opinions upon these genetic questions.[1] Dr. Bergeat first discusses the iron-ore deposits of Lapland, accepting as incontrovertible their magmatic origin, and merely pointing out the differences between Geijer's and Stutzer's interpretations; he then proceeds to examine the literature of the middle Swedish iron-ore deposits, from which he finds that there are three different views. According to Holmquist, these deposits are all of sedimentary origin. Johansson, on the other hand, supposes, in the most comprehensive manner, that both the iron-ores and all the accompanying rocks are nothing else than differentiation products from a common mother magma. Sjögren, finally, regards such an origin as possible for the apatite-bearing ores of Grängesberg, but asserts that the remaining deposits are the result of epigenetic metasomatic introductions into pre-existing rocks. He believes that they are to be referred back to pegmatitic exudations from a deep-seated magma. The actual present form of the deposits may have been determined by secondary processes acting near the surface at various times under the influence of meteoric agencies and producing an enrichment of the metal contents of the ores.

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[1] *Fortschritte der Min., Krist., u. Petrog.*, I, pp. 141-158, (1911).

TABLE 3.—*Genetic position of certain Swedish ore-deposits according to various text-books.*

——	Beck and Weed, 1905.	Stelzner-Bergeat, 1904-1906.	Beck, 1909.	Beyschlag-Krusch-Vogt,[1] 1910.	Probable origin.
Kiirunavaara (Fe)	Magmatic segregation.	Stratified ore-deposits-sedimentary in part (Schichtigen Lagerstatten).	Magmatic segregation.	Magmatic segregation.	Magmatic segregation.
Luossavaara (Fe)	Ditto		Ditto	Ditto	Ditto.
Gellivare (Fe)	Sedimentary.		Ditto	Ditto	Metamorphosed magmatic segregation.
Grängesberg (Fe)	Ditto		Grouped as sedimentary for convenience, but position regarded as doubtful.	Contact deposit.	Ditto.
Norberg (Fe)	Ditto			....	Doubtful: but not sedimentary. Probably largely epigenetic and related to metasomatic contact-metamorphic deposits.
Persberg (Fe)	Ditto			Contact deposit.	
Dannemora (Fe)	Ditto			Ditto	
Långban (Fe, Mn)	Ditto		Contact-metamorphic.	Ditto	
Sala (Pb, Ag)	Contact-metamorphic.	Metasomatic contact deposit.	Ditto	....	
Falun (Cu)	Epigenetic in crystalline schists.	Injection or non-metasomatic contact-deposit.	Epigenetic ore-bed or layer (Erzlager).	Magmatic segregation (Intrusive).	Epigenetic and related to contact-metamorphic deposits.
Åmmeberg (Zn)	Ditto	Stratified (sedimentary).	Ditto	....	
Kallmora (Norberg) (Pb, Ag)	Ditto		Ditto	....	
Taberg (Fe, Ti)	Magmatic segregation.	Eruptive	Magmatic segregation.	Magmatic segregation.	Magmatic segregation.

[1] Only Vol. I received.

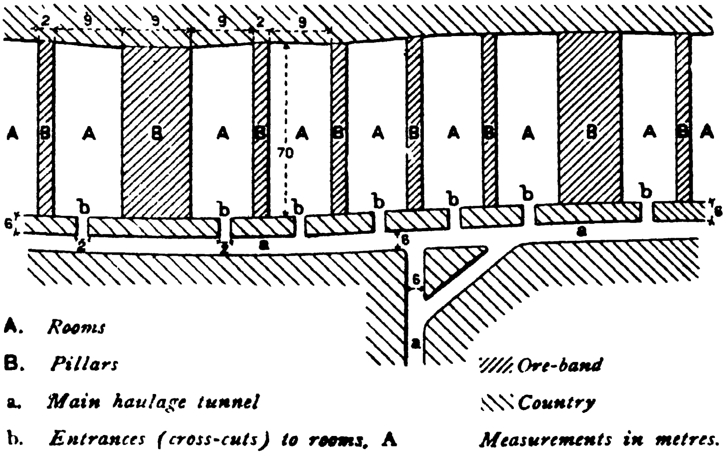
IV.—MAGAZINE METHODS OF MINING SWEDISH IRON-ORES.

One of my chief objects in visiting the Laponian iron mines was to examine the methods used for mining underground bodies of ore of considerable thickness; for it is possible that a few years from now it will be necessary in certain mines in the Central Provinces to resort to underground mining on ore-bodies which are in some cases 50 feet or more thick. Underground mining is now being carried out on the Tingvallskulle section of the Gellivare mine. The methods applied are the result of considerable experiment, and have the advantage of winning the ore-body with a minimum of pillars, of galleries for transport, and of timbering. The methods used have been fully described in a paper, entitled *Étude sur les Minerais de fer Scandinaves*[1] written by M. P. Nicou. I propose to give here a free translation of a few pages of this paper (pp. 105-111) for the benefit of Indian miners. I have left the measurements in metres, but in making practical use of these figures it will be near enough to assume that 1 metre is equal to 3 feet.

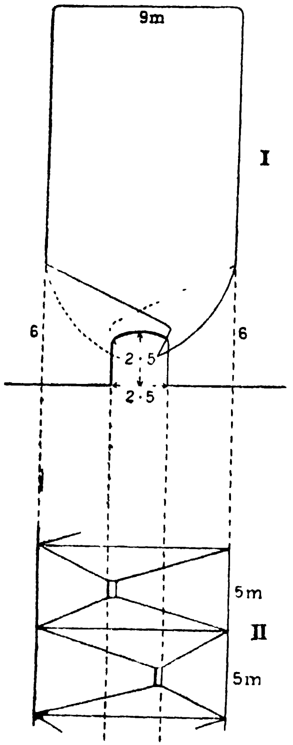
A main gallery or haulage tunnel with a cross-section of 6 metres by 4½ metres with three lines of rails, has been driven in at the 160 m. level from the northern face of the hill across the enclosing rocks up to the foot-wall of the mineral deposit, which here strikes in a general east-west direction and dips to the south at about 50°. A tunnel is now being driven east and west parallel to the deposit and in the barren country, and is to be carried as far as the Sofia mine to the west. The length of the tunnel from the entrance on the hill-side to the foot-wall of the deposit is 450 metres, whilst in the westerly direction it will be more than 1,300 metres long and will serve as the passage way for the ore won from the Sofia, Josefina, Vulkan, Lars, and Uppland mines.

Starting from this main road, secondary galleries or cross-cuts are driven, generally at right angles to it, traversing the mineral deposit across its whole width from the foot-wall to the hanging wall. These cross-cuts are placed at 11 metres from one another and have a transverse section of 2½ by 2½ metres; and at every 5 metres placed alternately against either wall, there is a trapdoor in the roof. (See fig. 2).

FIG. 1.



Ann. Mines, Serie 6, Tome XIX, pp. 85-174, 177-240, 249-376 (1911).



I. *Vertical Section*
II. *Arrangement of trap-doors & shoots.*
FIG. 2.

Once these cross-cuts have been driven the work of excavation (see fig. 1) consists in opening up, at a height of 6 metres above the floor and over a width of 9 metres—the length being equal to the width of the deposit—an excavation about two metres high, from which the ore is extracted by shoots cut in the ore mass and closed by the trap-doors already mentioned. Two shafts, opened at the two ends of this excavation in the deposit, and communicating with the secondary gallery, serve as passes for the workmen, ensure ventilation, and permit the passage of the compressed air-pipes necessary for the drilling. Once this preliminary work has been finished, the miners, working in the space or room thus formed, break down the ore by overhead stoping; only such quantities of ore are removed through the shoots as will always leave the workmen standing room of about 2 metres height above the broken ore and thus permit them conveniently to drill their blast holes. Whilst the work is thus progressing, the two terminal passes are built up at the same rate, whilst the quantity of available ore under the feet of the miners and above the trap-doors is being constantly augmented. The space made in the ore and filled by the greater portion of the ore mined, forms a sort of great reservoir or magazine of valuable ore, from which is derived the name *Magazine Method* by which this process of exploitation used in Sweden is customarily called.

The stoping is continued upwards until there remains only a small slice, two to three metres thick, which is left to prevent the higher level of the mine from falling in. This slice may be very much reduced in certain places, especially when the work is being carried up into open-cast workings; thus it is completely suppressed in some places at Grängesberg; it may be, on the other hand, very considerable, in places where the ore offers little resistance to crushing.

When the work of stoping is finished, the magazine may be emptied by the trap-doors at the bottom, destroying, when necessary, such obstructions as may occur, by means of explosives. There is thus formed a great cavity which will ultimately be filled by the caving-in of the upper parts or of the hanging-wall. In this manner the ore is extracted from great rooms 9 metres wide and of a length equal to the cross-section of the ore deposit, but not usually, in the most favourable cases, exceeding 100 metres; in excess of this length it would be necessary to modify the procedure slightly. The main haulage roads for the different sections of the work will be situated at intervals of 40 metres vertically below each other; this, allowing for the 6 metres' height of cross-cuts and shoots and for the slice, three metres thick, in the roof, will give the rooms a height of 31 metres. By placing the secondary galleries or cross-cuts 11 metres apart from axis to axis and giving to the rooms the preceding width, there are left between neighbouring rooms separating and protecting pillars 2 metres thick. When the rooms are emptied, these pillars break in, and a large proportion of their ore is thus recovered. As for the bottom slices, 3½ metres thick above the cross-cuts and six metres between them, a great part of them would probably be won, once the magazine had been emptied, by breaking the ore down into the cross-cuts. The roof slices should also tumble in, but, if not, their fall may be facilitated by a shot when the stoping is finished.

Further, in order to divide off independent sections for stoping, so that work in one does not interfere with the exploitation of others, the magazines are arranged in groups of 5, one group being separated from the next by a great pillar 9 metres thick. These pillars may be drawn by a process similar to that employed at Grängesberg.

It is interesting to calculate the amount of ore that will be obtained from one magazine in the normal case of a length of 85 metres; its horizontal section would then be 765 square metres, and its volume for a height of 31 metres would be 23,715 cubic metres. Assuming a specific gravity of 4·8 for the ore and 75 per cent. of the total volume to be ore (the remainder consisting of barren intercalations and patches), such a chamber would give 85,500 metric tons of ore, without reckoning that obtainable from the pillars and slices.

At Tingvallskulle it will be possible to carry on the exploitation by this method at 3 levels below that of 160 metres, *viz.*, at 200, 240 and 280 metres, assuming that the vertical distance between two levels is fixed at 40 metres.

The method employed at Grängesberg for drawing the 9 metre pillars remaining between each section of the magazine excavations—these excavations are already filled, either by the caving of the hanging wall, or, if open to the air, by means of materials thrown in from the surface—is as follows :

From the floor of the main haulage gallery a cross-cut is driven along the axis of the pillar; starting from this secondary gallery and at about its middle, a rise is put up to serve as a pass for the workmen, ventilation, and compressed air-pipes, and also for the extraction of the products; for this object it is divided into two compartments by wooden partitioning. This pass is carried up to a point 3 metres below the haulage level of the higher series of excavations, and starting from this point the ore is extracted on the descent in successive horizontal slices 5 metres thick. These slices are treated in the following way: starting from the pass a longitudinal tunnel is driven in the pillar parallel to the gallery at the base, and the ore is then broken down from both ends and both sides to a height of 3½ metres, the overlying 1½ metres being recovered afterwards by caving, stimulated, if necessary, by a little blasting. Some of the filling of the magazines may give way with the ore, and consequently a certain quantity of the ore may be lost through admixture; but it is estimated that, by combining with the magazine method of excavation, this method of winning the pillars, the total loss of ore, that is to say, the quantity not won, will not exceed 10 per cent. of the total. This caving system, which seems likely to find considerable application in Sweden, has, of course, been introduced from the Lake Superior region of America.

The magazine method as described above is that suitable for application to deposits of considerable width. On the Grängesberg field not only is this *transverse magazine method* in operation, but also, a modification with longitudinal rooms is employed for the exploitation of lenses of only moderate or small thickness, the details of which any mining engineer could work out for himself; this is known as the *longitudinal magazine method.* It will be time enough to consider the exact applicability of transverse and longitudinal magazine methods of exploitation when it is found necessary to resort to underground mining of the Indian manganese-ore deposits, which is not so very far distant in some cases, or of the iron-ore deposits, which is not likely to be necessary for many years to come. But I understand that the method should be applied *transversly* if the ore-body is 20 metres (say 60 feet), wide or over, and *longitudinally* if less. Moreover, the angle of dip of the deposit should be by preference not less than 50°.

V.—OVERTHRUST FAULTING.

One of the most fascinating features in the geology of Scandinavia is the zone of overthrust faulting that has been traced for about 600 miles along the eastern border of the Scandinavian Alps, which form the water-shed of the peninsula, the rivers from the eastern slopes flowing into the Gulf of Bothnia and those from the western slopes into the Atlantic Ocean. This range of mountains also forms for a considerable proportion of its length the boundary between Norway and Sweden, and throughout most of the northern portion of this boundary the overthrust areas lie in Sweden. Broadly speaking, the overthrusting consists of a driving from west-north-west of rocks ranging in age from Archæan to Silurian on to the comparatively undisturbed[1] older Palæozoics and Archæan rocks of Sweden. The overthrust phenomena were studied by the Congress in two parts of Sweden, *viz.*, in Jämtland, and, much further to the north, in the neighbourhood of Torneträsk in the Arctic circle, the centre for the latter excursions being Abisko. I did not take part in the Jämtland excursion, but a few remarks on the phenomena there observed, as described in Guide No. 2, entitled 'Studies in the Post-Silurian Thrust Region of Jämtland,' by A. G. Högbom, will be in place. As observed in that region, the undisturbed basis on to which the rocks have been thrust consists of Palæozoic rocks ranging in age from Cambrian to Silurian, resting upon Archæan rocks, which are mainly granites and porphyries. The rocks thrust on to these are in ascending order:—

Jamtland.

(1) The Åre and Sparagmite schists, grouped as the Seve schists, the Seve schists being the crystalline facies, that is to say the metamorphosed representatives, of the Sparagmite series, which is composed of quartzites, limestones and conglomerates to the east, with a more argillaceous

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[1] *i. e.*, with reference to these overthrusting (Caledonian) earth-movements.

facies to the west. The Seve rocks are regarded as of Algonkian age and roughly equivalent to the Torridonian rocks of Scotland. They rest directly upon the undisturbed Silurian and Archæan rocks.

(2) Overlying the Seve group, come the Koli schists, which are the metamorphosed equivalents of the Cambro-Silurian series.

The total original thickness of the overthrust mass of rocks cannot now be stated owing to the action of denudation, but judging from the mountain Åreskutan, it must have been at least 4,500 feet. The distance over which this mass has been carried in Jämtland is estimated by Högbom as not less than 140 kilometres (87 miles). In addition to the main thrust-plane in Jämtland, subsidiary thrust-planes have been detected in places in the overthrust masses. In many places, the basal rocks of the overthrust mass have been mylonitised, giving rise to mylonitic quartzites, slates and schists.

Lapland.

Let us now turn to the Torneträsk area, for a description of which reference may be made to Guide No. 6 of the Congress, entitled 'Die Hochgebirgsbildungen am Torneträsk in Lappland', by P. J. Holmquist, under whose guidance the members of excursion A. 2 examined some of the most important localities. In the Torneträsk area, there is a foundation of Archæan rocks (*Grundgebirge* or *Urgebirge*) consisting of granites of two distinct kinds, syenite, gneiss, schist, and greenstone. Upon this foundation rest Cambrian rocks [1], the junction between the Archæan and Cambrian being marked by a Cambrian conglomerate. Resting upon this are the rocks of the so-called *Hochgebirge*, consisting of cataclastic and crystalline representatives of the older Palæozoics, corresponding to the Koli group of Jämtland, together with rocks known as *Harteschiefer*, with dolomites, garnets, mica-schists and amphibolites, representing the Seve group of Jämtland. These rocks are usually in inverted sequence, and the true significance of some of them has not yet been deciphered. They all, however, occur as overthrust masses resting upon each other or upon the undisturbed Palæozoics and Archæan rocks.

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[1] In Holmquist's Guide they are spoken of as *Silurian*, but in Swedish Geology the term 'Silurian' is used in a comprehensive sense to include the British Silurian, Ordovician and Cambrian rocks, our Silurian being known as the *Gothlandian* in Swedish Geology after the island of Gothland or Visby in the Baltic, which consists entirely of rocks of this formation.

There is also a very important cataclastic rock resting in many places directly upon the Cambrian rocks, from which it is separated by the main overthrust plane. This cataclastic rock varies in aspect from that of a quartzite to that of a hälleflinta, and was for long a great puzzle to Swedish geologists; it was named *kakirite* by F. Svenonius after Lake Kakir some 50 miles to the south-west, where such rocks also occur. It has, however, now been discovered, by the aid of microscopical study and chemical analysis, that the kakirites are really the same as the Scottish mylonites in origin. In some places, as on Luopahta, the kakirites have the composition of syenites; in other places, as on Kaisapakte, they have the composition of granites, and in still other places, their composition corresponds with that of other Archæan rocks. The interesting point, on which Holmquist lays great stress, is the fact that where the kakirite has the composition of syenite, the fundamental rock is also a syenite and where the kakirite has the composition of granite, the fundamental rock is also a granite, and so on. This was well illustrated by our excursion to Luopahta. Leaving Stenbacken, we ascended through woods of dwarf birch, and soon emerged upon a bare open plain of syenite. A little further to the south, we came upon the basal Cambrian conglomerate resting directly upon the eroded syenite, the actual junction being visible. We then ascended over a series of good exposures of sandstones, limestones and slates, from some members of which Cambrian fossils (*Arionellus primævus*, *Ellipsocephalus Nordenskiöldi*, *Obolus*, *Platysolenites antiquissimus*) have been obtained. The top member of this limestone series was a crushed black clay-slate, and resting upon this, from which it was divided by an approximately horizontal plane, was a bed of kakirite giving rise to a vertical scarp, the physiographical aspect of the kakirite being similar to that of the Indian high-level laterite caps. The composition of the kakirite at this spot shows it to be a syenite similar to that crossed at the beginning of the excursion. Holmquist judges from this correspondence between the kakirite and the underlying Archæan rocks in this area, that the overthrust masses cannot have travelled through any such distance as has been attributed to them in Jämtland. Leaving Riksgränsen, which is the frontier railway station between Sweden and Norway, the railway descends rapidly to Narvik on the Ofoten Fjord on the Norwegian coast, and in this descent traverses Archæan granites with folded-in schists corresponding to the roots of the folds, the principal overthrust portions of which are seen in the Torneträsk area.

Although the phenomena of the overthrust faulting of Scandinavia are very similar to those of Scotland, yet there are certain differences worth noting. In Scotland, the thrust movement has taken place from east-south-east towards west-north-west, with the resultant overthrusting of the Eastern schists along the Moine thrust on to the Cambrian rocks and underlying Torridonian quartzites and Lewisian gneisses. The age of the overthrusting of Scotland (known as the Caledonian folding) is post-Cambrian and pre-Devonian. In Scandinavia, the western schistose facies of the Seve group and of the old Palæozoics, *viz.*, the Seve schists and the Koli schists, have been thrust from west-north-west to east-south-east on to the lower Palæozoics, the Sparagmite series, and the Archæan rocks, whilst the age of the Scandinavian overthrust is post-Silurian continuing into Devonian time. In Scotland, the maximum known distance of overthrusting is about 10 miles, whilst in the Jämtland, as noted above, the distance of overthrusting is considered to be as great as 87 miles.

VI.—COLLECTION OF MINERAL SPECIMENS.

During the excursions with the Congress, I took the opportunity to collect specimens for the Geological Museum, Calcutta. The collection obtained comprises some 200 specimens representing the rocks and minerals of the ore-deposits of Lapland and Central Sweden, and of the Archæan regions round Stockholm. Amongst the rocks are specimens of *leptite*, *hälleflinta*, *skarn*, *sköl*, and *kakirite*, all frequently mentioned in Swedish geological papers, and the possible source of much trouble to the reader in the absence of illustrative specimens. Of the minerals collected the following are worth mention:—

Locality.	Mineral.	Composition.
Ytterby . .	Fergusonite . .	(Y,Er,Ce) (Nb,Ta) O_4 with uranium.
	Gadolinite . .	$2BeO.FeO.2Y_2O_3.2SiO_2$.
Utö . . .	Petalite . .	$LiAl(Si_2O_5)_2$
	Lepidolite . .	Lithia-mica.
Stripåsen . .	*Damourite pseud. after topaz. .	Allied to muscovite.

Locality.	Mineral.	Composition.	
Falun	*Galenobismuthite	$PbS.Bi_2(S, Se)_3$.	
	Falunite	Altered cordierite.	
Långban	Native lead	Pb.	
	Hausmannite	$MnO.Mn_2O_3$.	
	Braunite	$3Mn_2O_3. MnSiO_3$.	
	Schefferite	Manganese-pyroxene	Mn silicates.
	Rhodonite	Manganese-pyroxene	
	Richterite	Manganese-amphibole	
	Mangan-garnet	Manganese-garnet	
	Tephroite	Manganese-olivine	
	Manganophyllite	Manganese-mica	
	Inesite	$2(Mn, Ca)SiO_3+H_2O$.	
	Kentrolite	$Pb_2Mn_2Si_2O_9$	Pb Mn silicate.
	*Barysilite	$Pb_3Si\ O_7$	Pb silicate.
	Berzeliite	$(Ca, Mg. Mn)_3\ As_2O_8$	Mn arsenates.
	Caryinite	$(Pb,Mn,Ca,Mg)_3As_2O_8$	Pb Mn arsenate.
	Hedyphane	$(PbCl)\ (Pb, Ca)_4\ (AsO_4)_3$	Pb arsenates.
	*Ekdemite	$Pb_6\ Cl_2As_2O_7$	
	*Pinakiolite	$3MgO.B_2O_3+MnO.Mn_2O_3$.	
	*Pyroaurite	$Fe(OH)_3.3Mg(OH)_2.3H_2O$.	
	Apophyllite	Lamellar.	
Jakobsberg	Hausmannite	$Mn_3\ O$.	
	Jakobsite	$(Mn,Mg)O.(Fe,Mn)_2O_3$.	
	*Ganomalite	$Pb_3(Ca,Mn)_2Si_3O_{11}$	Pb Mn silicate.
	Manganepidote	Allied to piedmontite	Mn silicates.
Nordmark	Pyrosmalite	$H_7[(Fe,Mn)Cl](Fe, Mn)_4(SiO_4)_4$	
	Allactite	$Mn_7(OH)_8\ As_2O_8$	Mn arsenates.
	Berzeliite	..	
	Diopside	Good crystals.	
	Calcite	,,	
	Magnetite	,,	
	*Tabergite	A chlorite.	
	*Kobellite	$2PbS.(Bi,Sb)_2S_3$.	

* Minerals new to the Geological Museum, Calcutta.

In addition specimens were obtained of various ores:—magnetite, hematite, pyrite, chalcopyrite, galena, blende, arsenopyrite, and molybdenite, as well as of serpentine, fluorite, and epidote.

With reference particularly to Långban (see the foregoing list), it is interesting to notice that a considerable proportion of the minerals are either silicates or arsenates of manganese, or of lead, or of both.

Perhaps the most exciting personal find was the discovery of a layer of richterite-kentrolite-rock[1] traversed by veinlets of native lead, whilst examining *in situ* in the Norrbotten pit of the Långban mine, under the guidance of a Swedish miner, an excellent section of *manganskarn,* the minerals occurring in other bands of this skarn being richterite, tephroite, and garnet. In another place I measured the following section :—

feet.	ins.	
3	0	Hausmannite in dolomite.
1	0	Dolomite (with skarn minerals).
0	9	Hematite in dolomite.
0	6	Tephroite.
1	0	Hausmannite in dolomite.
0	2	Tephroite.
0	1	Schefferite.
0	2	Rhodonite.

6 ft. 8 ins.

Also worthy of mention is a series of specimens illustrating the conversion of hematite into magnetite at the contact with a thick pegmatite dyke cutting across the iron-ore deposit in the Skärningen pit at Grängesberg. An interesting characteristic of these Grängesberg pegmatites is the presence of cavities filled with liquid pitch or asphaltum, to the presence of which one is tempted to attribute the reducing effects of the pegmatite on the hematite. Unfortunately I had no means of collecting specimens of this material. Advocates of an inorganic origin for petroleum should be interested in this occurrence, as also in the fact that similar substances have been found in many of the iron-ore deposits of Central Sweden both in the deposits themselves and in the pegmatite veins.[2]

Plate 29 shows photographs of two striking specimens: fig. 1, from Nordmark, is a very beautiful mass of scalenohedral crystals of calcite, with minute pyrite inclusions, and fig. 2 represents asbest-hedyphane, a fibrous variety of hedyphane from Långban.

Of the Långban specimens many were presented by Mr. H. V. Tiberg, of Långbanshyttan, who had arranged round his lawn small heaps of the characteristic Långban minerals for the members of the excursion to select from: others were collected by me personally in the Norrbotten pit of Långban, and the remainder were obtained by purchase. Some of the Jakobsberg specimens, also were collected personally, and some by purchase. For some of the Nordmark specimens I have to thank the generosity of Mr. C. J. Carlson of Filipstad, the remaining specimens from this locality being purchased.

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[1] Thought to be melanotekite when collected.

[2] See Stelzner-Bergeat, Die Erzlagerstätten I, p. 122, footnote, (1904).

EXPLANATION OF PLATE.

PLATE 29.— FIG. 1.—Calcite from Nordmark, Sweden.
,, ,, ,, 2.—Asbestiform Hedyphane from Långban, Sweden.

MISCELLANEOUS NOTES.

Notes on some Nummulites from the Burma Tertiaries.

Mr. Tipper in his memoir on the Andaman Islands (*Mem. Geol. Sur. Ind.*, XXXV, pt. 4, p. 6) quotes the occurrence of *Nummulites atacicus* and *Assilina granulosa* amongst the collections of Mr. Datta from Burma, thus proving the existence of the Laki group in this province. Last year Mr. Sethu Rama Rau collected specimens of *N. atacicus* from the same horizon, but to the north of the region which Mr. Datta worked over, when crossing the Arrakan Yoma. It seems advisable to give a list of the localities of these fossils for purposes of future reference.

The following is a list of the localities where Mr. Datta found nummulites during his traverse; the information being taken from an unpublished report:—

(1) Not quite ½ mile W. of Kyimi village, lat. 19° 33′, long. 94° 41′ 30″, sheet 114 Burma Surveys.

(2) "Proceeding S. E. from Kyimi, the outcrop can be followed more or less continuously by means of surface debris to Kondeingon" (a deserted village not marked on the map).

(3) ½ mile N. by W. of Pebingon, lat. 19° 28′, long. 94° 41′, sheet 115.

Mr. Datta found a limestone bed to the west of this nummulitic bed, halfway between the villages of Kadeing (lat. 19° 22′, long. 94° 39′), and Pyugan (lat. 19°, 23½′, long. 94° 41′) which he states is again visible 1¼ miles W. of Ywathit (lat. 19° 15′, long. 94° 44′). He points out that this last locality is the one referred to by Theobald (*Rec. Geol. Sur. Ind.*, IV, pt. 2, p. 36, sqq.). This is the locality from which Mr. Tipper identified *Cardita beaumonti*, a species of Upper Cretaceous age (*Rec. Geol. Sur. Ind.*, XXXV, p. 119). It seems clear then that this limestone is Cretaceous, and that the Lakis are underlain by the Cretaceous or "Chin Shale series" on the eastern flanks of this part of the Arrakan Yoma. The locality from which Triassic fossils were found by Theobald is 1½ miles S.W. of Thabyegaing (lat. 19° 2′, long. 94° 57′,) in sheet 116. The relations of the Triassics to the Cretaceous in the area are not known.

The specimens of *N. atacicus* brought by Mr. Sethu Rama Rau are from a locality in sheet 114, 12 miles N.N.W. of the village of Kyimi, where Mr. Datta found his nummulite bed, and they obviously come from rocks of the same age. The locality is 1½ miles W. by S. of

Kazet village (lat. 19° 42′ 20″, long. 94° 38′ 30″). If the lines of strike are continued northwards to sheet 112, with which area my paper on the Pegu-Eocene Succession in the Minbu District (*Rec. Geol. Sur. Ind.* XLI, Pt. 4.) deals, the part which I have mapped as Lower Eocene would correspond with these Laki beds.

Thus we apparently have in this part of Burma the equivalents of the Khirthars, Lakis, and Pab Sandstones of India.

[G. DE P. COTTER.]

Note on the Limestone Hill near Thayetmyo.

Theobald (*Mem. Geol. Sur. Ind.*, X. p. 107, sqq.) describes a hill-ridge about four miles S.S.W. of Thayetmyo as showing Nummulitic strata. It appears evident from his description that this hill is the same as that marked upon the Burma Survey one inch map (sheet 159) as Myinmagyitaung. Some of Theobald's specimens from this hill are registered in the Geological Survey catalogue under the numbers K-10-183 and K-10-185, the locality being stated as "5 miles south of Thayetmyo." These specimens contain three species of *Orthophragmina*, one of which is the same as that which I described as *O. omphalus* in *Rec. Geol. Sur. Ind.*, XLI. p. 234. The second species closely resembles *O. papyracea* var. *javana* (*see* Verbeek and Fenemma, Geol. of Java and Madoura, p. 940, and Pl. IX, f. 114), but I have not been able to develop the central cells. The third species is the largest, attaining a size of 7 cm. and has a corrugated margin, there being about eight corrugations round the whole circumference; these die out at about one half radius from the centre. The age of these is clearly Khirthar. But mixed with these specimens are some fragments of a Lepidocyclina limestone, in which the lepidocyclines are not identifiable. Mr. Sethu Rama Rau some years ago brought back from Myinmagyitaung some specimens of Lepidocyclina limestone, which appear to be the same as that of Theobald's collections. In these last specimens, the lepidocyclines are much better preserved. The size of these is 11-12 mm. or over; the central cells resemble those of *L. dilatata*, but I have not proved the presence of the small pillars which distinguish *L. dilatata* from *L. Raulini*. In any case these specimens appear to be of Nari age. It now appears probable that Theobald has included in his Nummulitic group beds of Oligocene age. On the other hand he has included the beds containing *L. Mantelli* var. *Theobaldi* in the Pegus (*op. cit.*, p. 87). This being so, it may be necessary to revise his boundary, so as to draw the lines between the Naris and the Khirthars.

[G. DE P. COTTER.]

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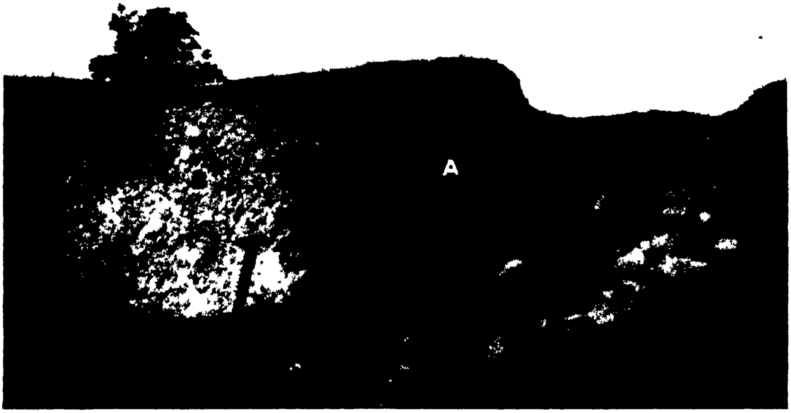

FIG 1 MANGANESE-ORE BEDS (A) CUT OFF BY PEGMATITE (B). GOWARI WARHONA CHHINDWARA DISTRICT

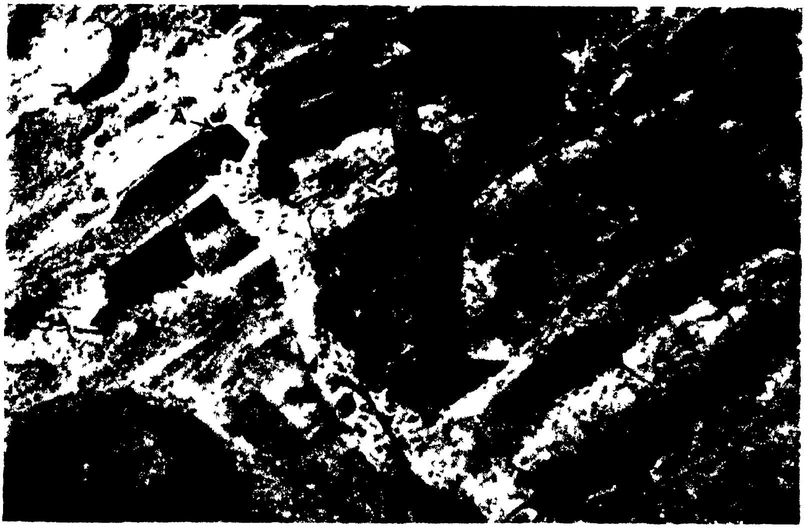

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FIG 2 PEGMATITE VEIN WITH AN INCLUDED PENTAGONAL FRAGMENT (A) OF MANGANESE-ORE, CUTTING MANGANESE-ORE BEDS

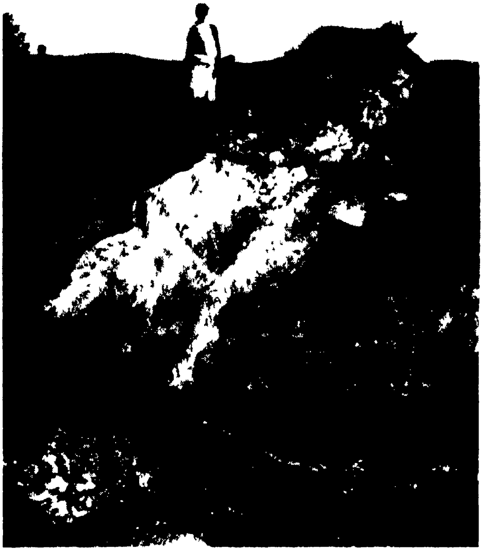

FIG 1 FELSPATHIC DYKE CUTTING MANGANESE-ORE BODY GOWARI WARHONA

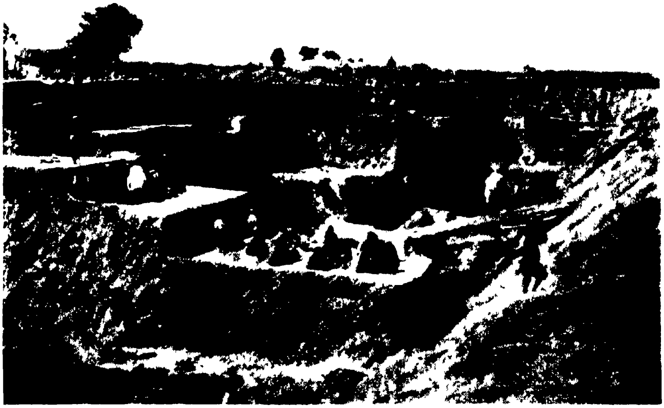

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FIG 2 GENERAL VIEW OF GOWARI WARHONA

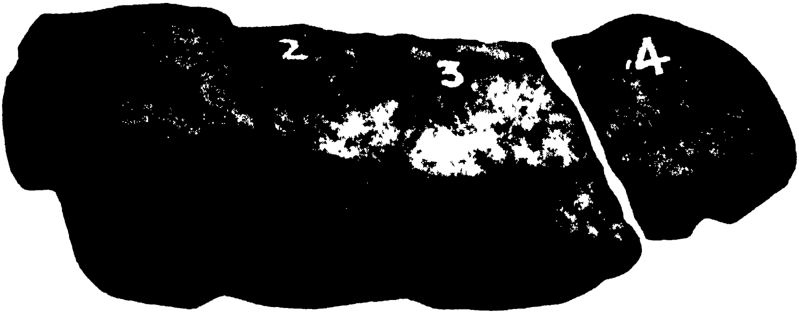


FIG. 1 JOINTED INCLUSION OF MANGANESE-ORE FROM PEGMATITE VEIN. X $\frac{1}{1}$

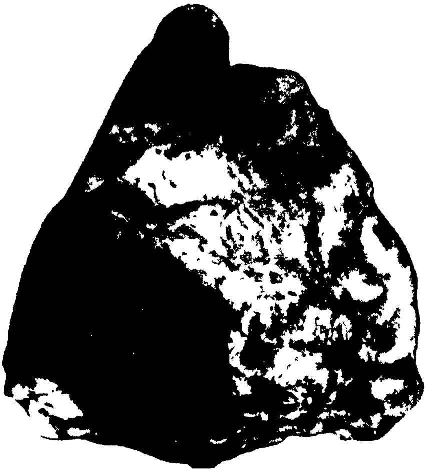
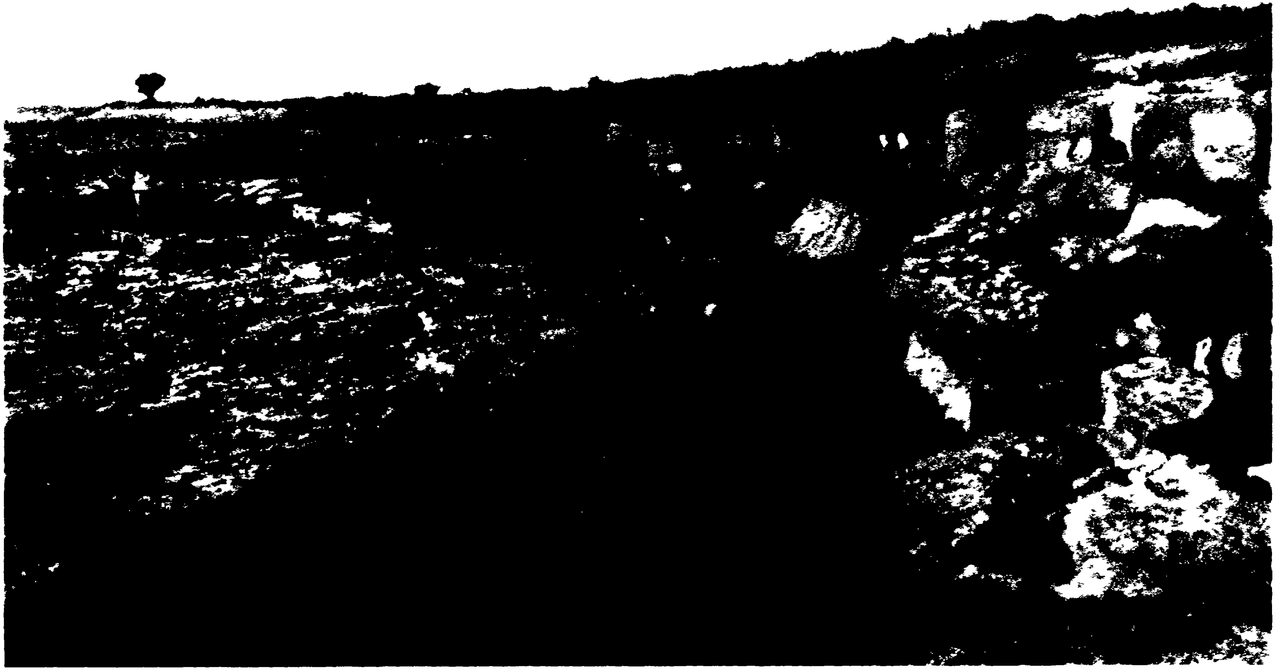


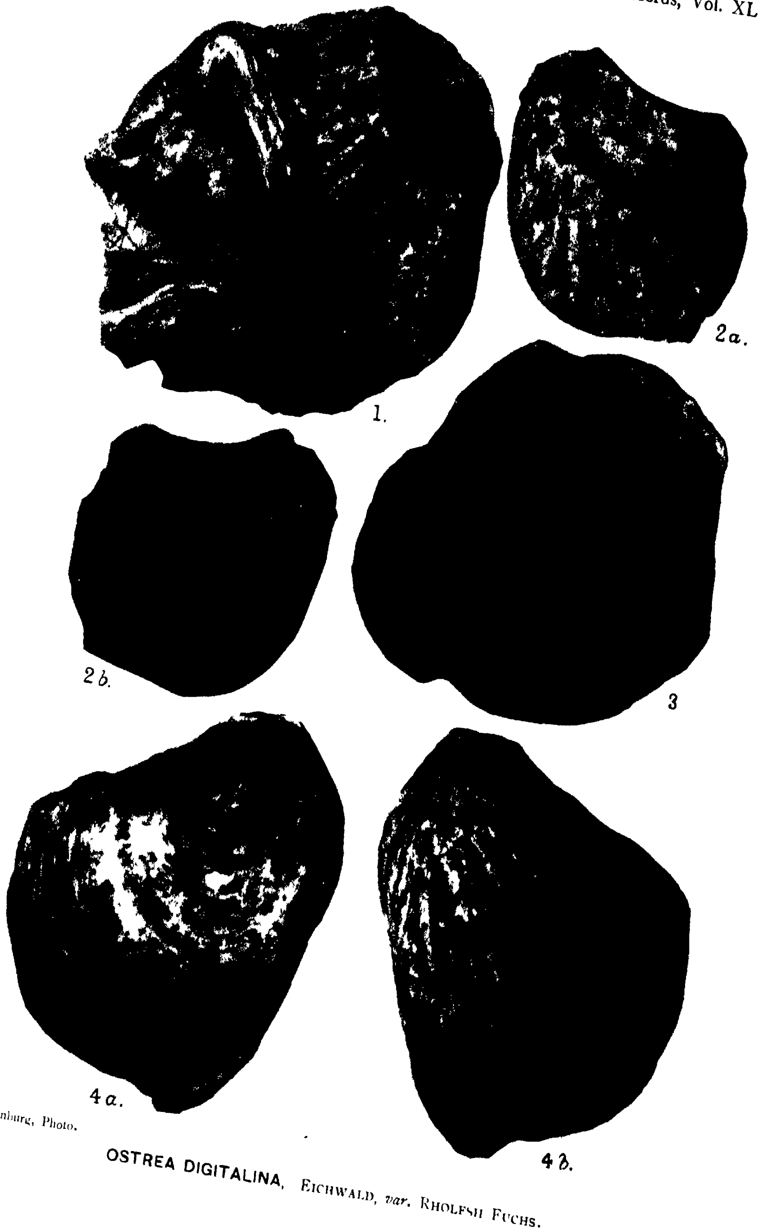
FIG. 2 INCLUSION OF MANGANESE-ORE IN PEGMATITE. X $\frac{1}{1}$

H. B. W. Garrick, Photo.

FIG. 3. INCLUSION OF MANGANESE-ORE IN PEGMATITE. X $\frac{1}{1}$



A. M. Heron, Photo



F. Vredenburg, Photo.

OSTREA DIGITALINA, Eichwald, *var.* Rholfsii Fuchs.

1 × 1¼

× 2½

4

3 × 1¼

2 × 2

5 × 2

6 × 2

nat. size

8*a*

nat. size

9

7 × 2½

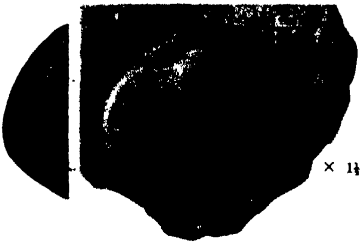
8 nat. size

nat. size

10

× 2½

11



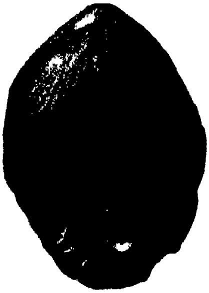
× 1¼

12

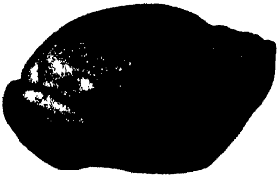
T. A. Brock del.

West, Newman collo.

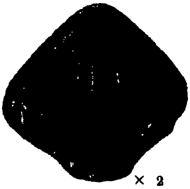
DEVONIAN FOSSILS FROM CHITRAL.



1 × 2

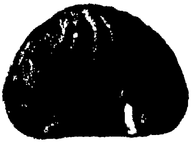


1a × 2



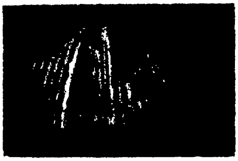
2 × 2

3 × 2

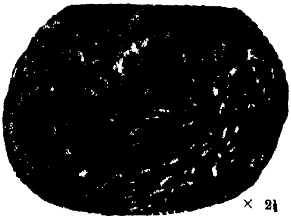


2a × 2

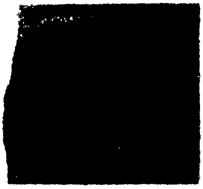
4 × 2



5 × 2

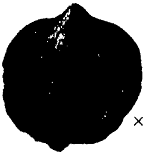


6 × 2½

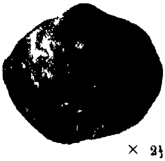


7 × 2½

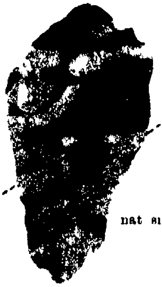
8 × 6



9 × 2½

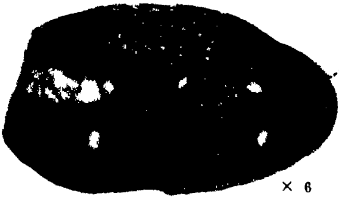


10 × 2½

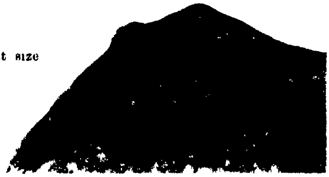


11 nat size

11b × 6



11a × 6

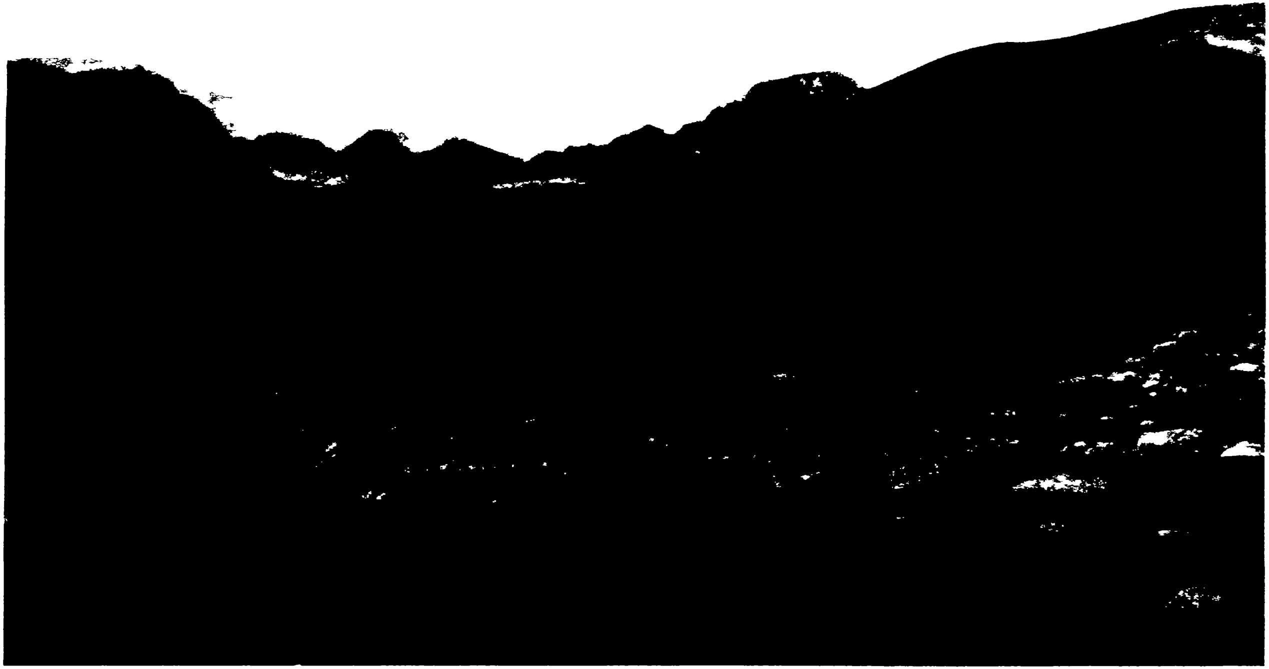


12 × 6

T A Brook del

West, Newman collo

DEVONIAN FOSSILS FROM AFGHANISTAN, ETC



C. S. Middlemiss Photo.

G. S I. Calcutta.

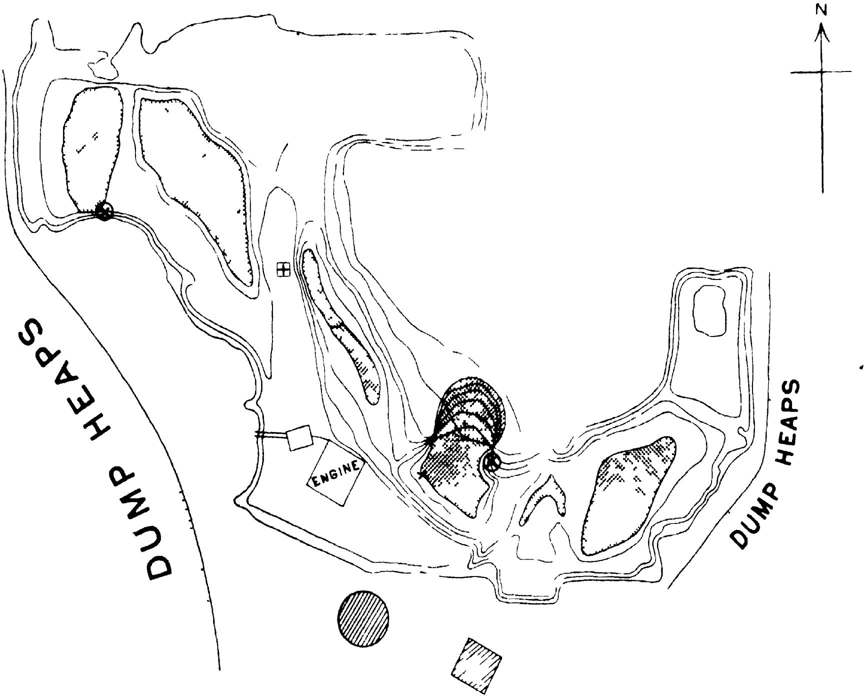
VIEW S. W. UP SANGSOFED R. TO NEAR TATAKU TI PEAK.

G. H. Tipper, Photo

SANKARA MICA MINE LOOKING N. W.

G. H. Tipper, Photo.

SANKARA MICA MINE SHOWING THE POSITION OF THE SAMARSKITE



▭ *Water* × *Samarskite* ⊞ *Cyrtolite*

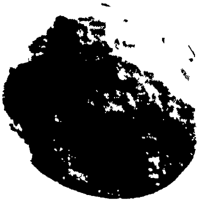
▨ *Prospecting pits* ⊗ „ *supposed finds* *Contouring only approximate.*

PLAN OF SANKARA MICA MINE

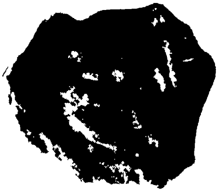
Scale 1 inch = 50 ft approximately

GEOLOGICAL SURVEY OF INDIA.

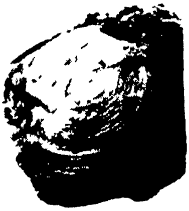
Records, Vol XLI, Pl 17



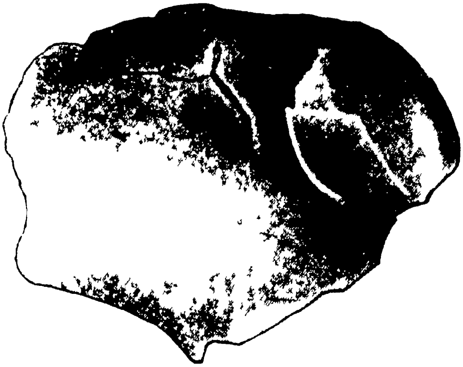
1 × $\frac{1}{1}$



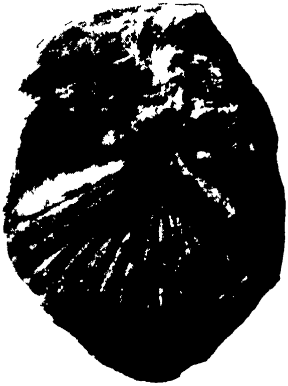
2 × $\frac{1}{1}$



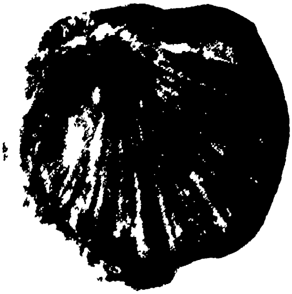
3 × $\frac{1}{1}$



4 × $\frac{1}{1}$

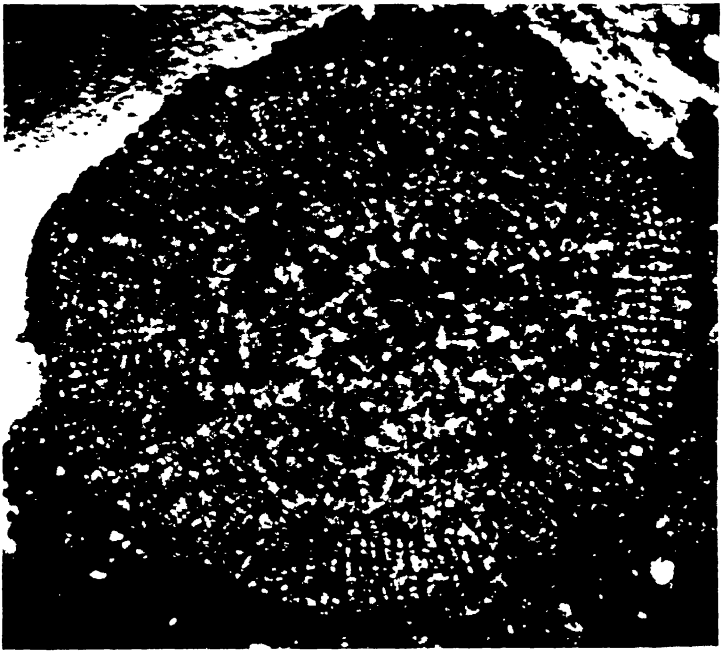


5 × $\frac{1}{1}$



S. Sethu Rama Rao, Photo. 6 × $\frac{1}{1}$ 7 × $\frac{1}{1}$

NARI FOSSILS FROM MINBU DISTRICT

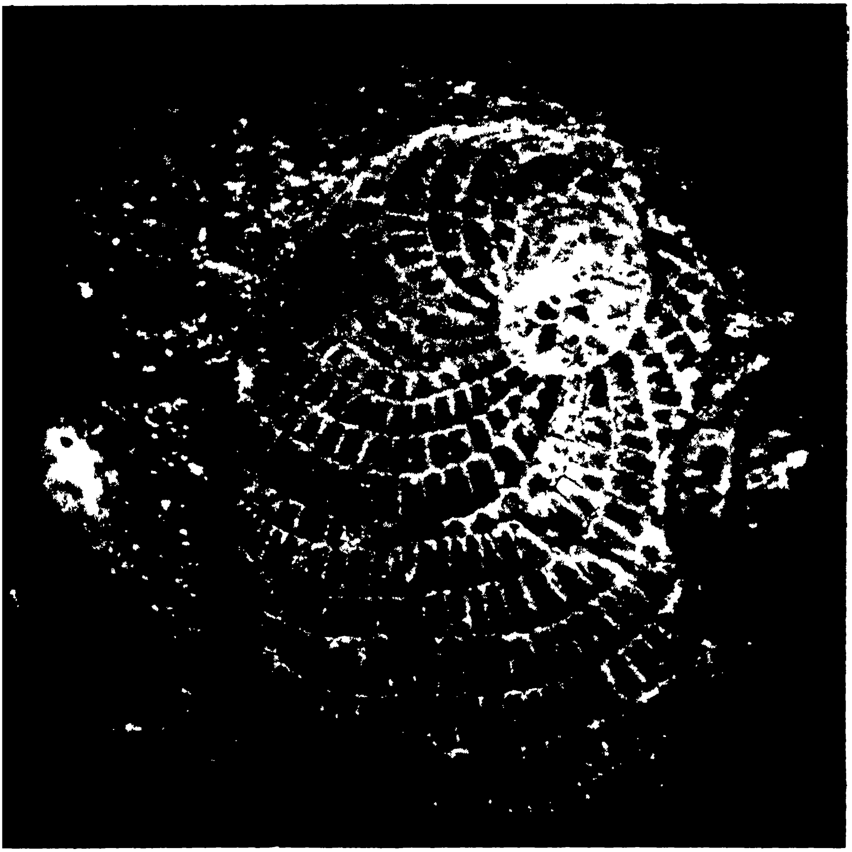


S Sethu Rama Rao, Photo. ×16

GYPSINA *sp. f.* GLOBULUS, Reuss

GEOLOGICAL SURVEY OF INDIA

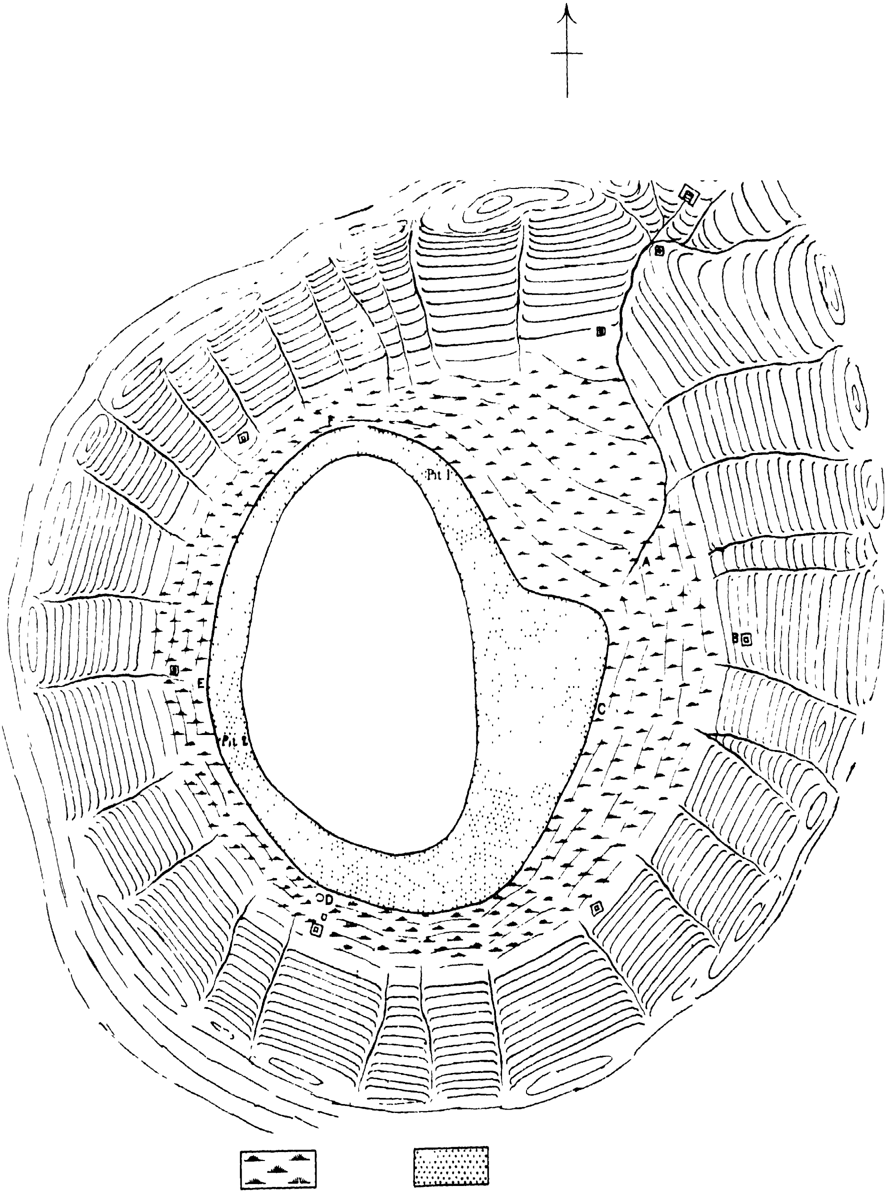
Records, Vol. XLI, Pl. 20.



S. Sethu Rama Rao, Micro photo.

16

HETEROSTEGINA *sp.*



PLAN OF THE LONAR LAKE.

Scale 1 inch = 1,200 feet.

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